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ABSTRACT

A lecture series was conducted in 1989 to present information on learning theories by learning theorists. This document contains short texts of the lectures; full texts are available on request. In lecture 1, Robert Chase discusses educational reform and Bonnie Guiton examines educational goals from the perspective of White House policy. In lecture 2, David Perkins considers thinking skills in the context of three types of intelligence, which he calls neural, experiential, and reflective. The differences in thinking and learning that occur in various contexts is examined in lecture 3 by John Seeley Brown. Reuven Feuerstein, in lecture 4, recounts the theory of mediated learning experience, which he developed. In lecture 5, Mihaly Csikszentmihalyi examines the role of student motivation in literacy learning. In lecture 6, Howard Gardner explains the seven domains of intelligence in his theory of multiple intelligences. Various types of electronic technologies that are being adopted for use in schools are reviewed by Bob Hughes in lecture 7. In lecture 8, Michael Templeton discusses informal education. A concluding section presents an overview of the lectures and applies the theories examined in the lectures to practices used in children's museums. (BC)

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How We Think and Learn

Lecture Series
presented by
The National Learning Center
Capital Children's Museum
Washington, DC

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The opinions expressed in this publication are those of the authors and are not necessarily those of the National Council on Vocational Education or the U.S. Department of Education.

Foreword

The lecture series, "How We Think and Learn", was initiated by The National Learning Center (TNLC) in fall 1989, in order to share with a larger audience some of the research of members of TNLC's advisory board. That board is organized as a group called the Institute for the Mind of the Child. Its purpose is to draw on the research of some of today's leading cognitive psychologists to guide the educational practices of TNLC and its three entities: the Capital Children's Museum, the Model Early Learning Center, and Options School.

Capital Children's Museum (CCM) is one of the first museums which opened as a wave of children's museums began to spread across America in the mid-1970's; it occupies three acres near the U.S. Capitol in Washington, D.C., and serves large numbers of inner city children because of its proximity to neighborhoods where they live. CCM is respected among the growing number of children's museums for its commitment and many programs which successfully serve the inner city. It is loved by its visitors for the enormous number of "hands-on" activities contained in its exhibits, and it is admired widely for the depth of concept which underlies its exhibits.

The Model Early Learning Center (MELC) and Options School were established by TNLC and opened in January 1990 as schools to serve inner city youth who are at risk for many factors. Both schools are run as cooperative endeavors of TNLC and the D.C. Public Schools (DCPS). DCPS selects the students and provides the funds; TNLC creates the programs and fully operates both schools which are housed in the same building as Capital Children's Museum and which make full use of museum facilities and staff as integral parts of their programs.

As TNLC expanded from the operation of a large children's museum to the operation of the museum and two schools, it determined that, more than ever before, it needed the guidance of persons whose life work is to study how learning occurs. Thus, it formed the Institute for the Mind of the Child. Institute members meet with TNLC staff on an occasional basis to discuss one or another of TNLC's programs; they provide TNLC with research papers, and they serve as a pool for other ad hoc advisory boards which TNLC creates to support various aspects of the Museum, the schools, and its other programs.

Drawing on the research of some of today's leading cognitive psychologists

This seminar was the first time this widely recognized group of psychologists were on the same program to offer a synthesis of their work for a lay audience. They came from afar to do so.

TNLC's first visible work with the Institute was in the public lecture series "How We Think and Learn". This book contains short versions of the papers presented by Institute members at the series. The series was broadened to include several persons whose work brings them in close contact with school and museum practice across America. Thus, in this book you will find remarks by a Vice President of the National Education Association, by the President's Consumer Affairs Advisor, by the National Science Foundation's former Program Director for Informal Science Education, and by a Vice President of the Boeing Company as well as opening and closing remarks by Ann Lewin, founder of The National Learning Center.

The series was conceived and coordinated by Louise Wiener, Assistant to the President of The National Learning Center, who worked closely with Anna Caraveli of the Smithsonian Institution to organize and publicize the series. Lectures were held in the Hirshhorn Auditorium at the Hirshhorn Museum between October and December 1989. The lectures were attended by 100 persons, many of whom were classroom teachers eager to hear first-hand from persons whose work is on the cutting edge in psychology.

Publication of talks in the series is made possible through the National Council for Vocational Education which believes that learning theory is essential to drive all educational practice.

Dr. Howard Gardner, Co-Director of Project Zero at Harvard University and one of today's leading developmental psychologists, referred to this series as "seminal" and commented that, as far as he knew, it was the first time this widely recognized group of psychologists were on the same program to offer a synthesis of their work for a lay audience. Each psychologist in turn commented that the series provided him with an unusual opportunity to address a lay audience and especially an audience of practitioners, and thus each took care to speak in terms familiar to such an audience. They came from afar to do so — Dr. Feuerstein from Jerusalem, Dr. Brown from Palo Alto, Dr. Csikszentmihalyi from Chicago, and Mr. Hughes from Seattle.

We present here the full text for each "introducer" and synopses of each psychologist's talk. Full texts of the psychologists' talks are available through The National Learning Center.

Deep appreciation is extended to each person who interrupted an overly full schedule to prepare a lecture and to travel to Washington to deliver it, to the Smithsonian for its cooperation, and especially to Louise Wiener for calling the series into existence and to Joyce Winterton and Julia Anderson for assuring that it will live on through this book and the available papers.

A framework for the lecture series "How We Think and Learn"

INTRODUCTION

From Theory to Practice

Ann W. Lewin
Founder and President
The National Learning Center
Washington, D.C.

The lecture series "How We Think and Learn" offers some of the latest learning theories presented by the men who developed them. These theories have powerful implications for practice in both formal and informal education. A theorist of a former era, Jean Piaget, the noted Swiss philosopher, epistemologist, psychologist and educator, developed a theory that we learn as a result of our own direct experience. Fifty years after Jean Piaget did his major work, schools and museums began to use his theory as the rationale for their practices. This concept of "direct experience" became both the basis for schools' use of manipulative materials and the raison d'etre for the new "hands-on" children's museums which spread rapidly across America and abroad in the 1970's and 1980's. But, by the time Piaget's theories had penetrated the public consciousness and had become entrenched, the leading edge of developmental psychology had moved beyond its founder's thinking.

Recently, there was a small gathering of seven of today's leading learning theorists, seven directors of children's museums, and seven teachers. One of the psychologists made the statement that only fifty years hence would the ideas proposed at the conference find their way into practice. A knowing look went around the room as all present acknowledged that this was true — and recognized that they would all be dead by then.

The lag time of fifty years or more from the development of a learning theory to its implementation is a critical issue because change is needed now. As our schools founder in the face of collapsing social systems and as our nation founders in the face of foreign economic competition, everyone turns to the schools as both the cause and the solution of the problems: if the

Educational practice can be thoughtfully changed only when the change is undergirded by a cogent theory

schools were functioning well, the nation would not be foundering and our economic problems would disappear.

The Business Round Table announces it will make education its priority. IBM says it will spend $81 million on education. The Xerox Corporation establishes a new Institute For Research on Learning, and CEO's pledge to make education a priority for themselves and their employees. But, while it is easy to agree on lofty statements of goals, statements which are written again and again, implementation rarely follows. Moreover, argument ensues about how to implement the goals, and the goals we accept are frequently based on theories which compete with or contradict one another. Even when we do agree on how to change schools, change is not instituted rapidly or efficiently.

The matter is complicated by the fact that our theories, which form the very fabric of our belief systems, are invisible to us. A pundit said, "We don't know who discovered water, but we know it wasn't the fish." So it is with our theories, we are not able to see or understand the theories which form our most basic beliefs and which drive our systems.

An old joke, retold by James Connor in an article he wrote for *The Journal of Developmental Education*, further explains:

> *A man was sent to a psychiatrist because he was convinced he was dead. No amount of conventional logic could persuade the patient that he was alive. Then the psychiatrist hit upon what he was sure was a clever strategy to change the man's irrational belief. He asked the patient, "Do dead men bleed?" The patient responded with a firm, "No, of course not." With this, the psychiatrist took a needle and pricked the patient's finger. With a look of utter astonishment, the patient stared at this finger and exclaimed: "What do you know? Dead men do bleed!"*

Our theories undergird our thinking about how our systems function. Systems, like theories, are made up of both limits and clearly defined sets of behaviors within these limits, and, our systems are as impervious to change as our theories. Cybernetics theory, which explains how systems behave, holds that there are three essential parameters of change: (1) all parts of the system must change (the limits and the behaviors); (2) the ultimate effect of the change cannot be predicted; and (3) once begun, change will continue. Such change is called paradigmatic, that is, change in which both the limits and the behaviors are affected. It is indeed hard to imagine that there will be paradigmatic change in our formal systems of education. In fact, the past three decade's "changes" have amounted merely to patches, while the paradigms on which the system rests remain intact. Yet, educational practice can be thoughtfully changed only when we have new paradigms, only when the change is undergirded by a powerful, cogent theory of how we learn.

Informal education systems may, in fact, provide a better opportunity to operate with a different paradigm than traditional formal school systems. And, it may be that we must look to informal education for some of the answers we are so desperately seeking in the schools. Among informal learning systems, children's museums in particular offer fertile ground for having an im-

pact on how we design environments that could foster children's learning. Unlike formal school systems, in which time is a key parameter, in a children's museum space is the key organizing factor. Schools are driven by clocks, bells, and periods, and whatever is done must fit in predetermined time frames. Children's museums are driven by spaces, placement of objects in those spaces, selection of objects in relation to one another, and most important, use of objects — which can be touched, worn, tasted, shaped, and climbed — to stimulate children's individual interests.

The critical issue to think about when we consider children's museums as systems that could drive new educational practice is the question of what theories will guide the practice in children's museums. If, swimming in the water of our time, we use the same theories that drive formal education, we will fail to realize the potential which the newness of children's museums offers. Reuven Feuerstein cautions against getting stuck with four myths — the myths of direct exposure, discovery learning, activity-based learning, and the need only for intrinsic motivation. These myths, he cautions, are part of the old thinking which took hold during the last decade of Piaget's life and became entrenched in the decades following his death.

The excitement of the ideas in this book, "How We Think and Learn" is that they are not formulated on the old theory. They offer the latest thoughts by a handful of psychologists who are formulating new theories. These men's ideas resonate with one another. Together, they offer guidance in the how and the what of a new educational order.

Changing all the parameters in educational systems means giving up sacred cows on school boards, in administrations, in teacher unions, in the classroom, in parent expectations, in the museum director's mind, and in its board's collective ego. In the 1990's changing the parameters also means that families will have to return to their pre-1970's role as the primary carrier of the culture, as the place where the values, expectations, and mores are transmitted from one generation to the next. The practical consequences of such shifts are enormous; the harbingers for change are few: Ted Sizer's Coalition of Essential Schools, the Guggenheim School in Chicago, Key School in Indianapolis, Junior High School 13 in East Harlem managed by Deborah Meier, the Chelsea project outside Boston, and the Options School run by The National Learning Center in Washington, D.C.

The new children's museums are harbingers for change because their "systems" are still in formation and therefore are fluid. Their nature is entrepreneurial, and their leaders, many of whom are the founders, are pioneering. Most have not come out of formal school systems, and those who have are people who have left hungry for change. The children's museums may be places to institute some of the changes which need to drive children's learning experiences. If so, children's museums could help to shorten the time between the formulation of a theory and its implementation; they could act as a bridge between theory and practice. Bridging theory and practice is a central theme of the series "How We Think and Learn".

Each of the main speakers in the series has a contribution to make in the effort now underway to change education. Two speakers are policy

Children's museums could act as a bridge between theory and practice, as a testing grounds for theories.

makers, three are practitioners, and five are learning theorists whose work is on the cutting edge in helping us understand how we learn and what, therefore, some keys are to effective learning environments. If these theorists' work will find its way into schools only fifty years hence, perhaps a key role for children's museums, which continue to proliferate rapidly, is as testing grounds for their theories, as places where we can experiment with ways to realize the theories in practice. The idea that children's museums offer an open environment in which to give new theories some play is another leitmotif of this lecture series.

We will hear first from Robert Chase, Vice President of the National Education Association (NEA), an organization generally considered a champion of the status quo. However, Chase's remarks are an eye-opener. He not only calls for change, he documents instances across America of the NEA's involvement in systemic change in public schools. More importantly, he pleads articulately for the right to take risks, to fail from time to time, and for the public understanding which must undergird the process of change.

Bonnie Guiton, the President's Consumer Affairs Advisor, has education under her purview. Her remarks look at change from the perspective of White House policy on education, and she speaks of the role of children's museums. She assures us that at the highest levels, there is an understanding of how great the need is to alter the business of education, and she speaks of what children's museums can do in this regard. Robert Hughes, our last speaker, talks about the kinds of electronic technologies schools are adopting.

The learning theorists were selected because each person's work touches a different aspect of the complex process of thinking and learning. Together, their theories form a rich mosaic. There are many implications in their work for change in school systems on a grand scale, for change in the particulars of classroom practice, and for a cogent theory around which to shape the emerging children's museums.

David Perkins presents an overview of three kinds of intelligence, the neural level over which we have little control, the knowledge base which we build gradually throughout our lives and which therefore is hard to change, and the processes in which we think about our own thinking. This latter, he says, is an accessible level which we can change, and he offers examples of how to do so. One is his highly useful analogy of a "cognitive Jiminy Cricket". We can, he says, "sit on our own shoulder" and watch ourself think; moreover, this level of thinking is easy to reach and improve. Perkins extends thinking to the tools for thinking such as a young child's use of fingers for counting, and the pencils and paper which enable us to figure and extend our memory. Thus, he sanctions and encourages as both legitimate and essential to the thinking process some of the tools which classroom practice denies.

John Seely Brown talks about situated learning, learning in context, and differences in three kinds of learners: the novice, the expert, and the school learner. In obvious and familiar examples, he shows that the novice and expert use similar strategies, but the school learner uses techniques that have little application outside the classroom. He suggests four kinds of learning-friendly behavior which is out-of-favor in the classroom: cooperative endeavors (too often called cheating in school), concrete tools versus abstract reasoning, use of tools rather than symbols, and an

emphasis on the use of stories rather than the presentation of facts.

Reuven Feuerstein recounts the theory he fathered: the mediated learning experience. This robust theory and Feuerstein's widespread applications of it provide evidence that mediation is an essential component of learning. Feuerstein offers many examples showing that mediation, or the lack of it, can significantly alter a person's cognitive functioning. In particular, the parent or teacher must be an effective mediator, and acting as mediator changes the nature of parent or teacher behavior. Two basic tenets of his theory are that cognitive structure can be modified and that we should assess not what a person currently knows or how he currently thinks but rather **the potential for change**. These ideas coupled with the idea of teacher recast as mediator carry the seeds of educational revolution.

Mihaly Csikszentmihalyi says that the key to learning is motivation; that without motivation it is unlikely learning will occur, but with it there is essentially no limit. He presents the concept of flow in which a person achieves a joyful, unconscious rhythm in his work, driven by his own motivation. His work is based in part on years of research conducted in the Chicago public schools where he "beeped" students in the classroom eight times daily to determine both what they were thinking and how they felt. His findings condemn classroom practice in which the sole mode is transmission of fact from teacher to student and lecture/question/ answer. These classrooms, he finds, turn off students' minds. As one example he uses a class on China in which twenty-eight of thirty students when "beeped" were thinking of things entirely unrelated to the lesson, one was wondering why so many Chinese wear a long black pigtail, and one was thinking about a recent meal in a Chinese restaurant.

Howard Gardner talks about our innate intelligence in the theory he fathered called "MI", or multiple intelligences theory. It states that there are seven kinds of thinking — mathematical/ logical, spatial, kinesthetic, musical, linguistic, interpersonal and intrapersonal. It says there is a separate domain for each of these intelligences and that intelligence does not generally transfer from one domain to another. Thus, each of us has a jagged profile of intelligence. When extended to school practice, this theory calls for restructuring to identify and nurture individual differences and brings an apprentice model into the mainstream of education.

The exciting thing about these five theorists is how many seeds for change are contained in their ideas. Moreover, each person has worked in robust projects with schools, in some cases, like Feuerstein, having his work adopted throughout an entire country; in other cases, like Csikszentmihalyi's, having more than two decades' experience in classrooms as a basis for his theory.

The challenge to the teacher, administrator, lay parent school board and founder of a children's museum is how to set policies which will clear the way for the ideas of leading edge theorists to be tried. The monolith of current educational practice and the underlying theories which drive that practice are seemingly impervious to change. Yet, we must penetrate that monolith with experiments which are based on the new theories of how we think and learn. The schools must open themselves to new ideas firmly

The theories in this book contain many seeds for change.

grounded in theory and to risk and experiment with models that address systemic change. The children's museums must look critically at their underlying beliefs about learning. Willingness to challenge our underlying assumptions and openness to sweeping change will save our children's minds from stultification and will insure that our nation prospers.

Short texts of each theorist's presentation follow. Full texts are available on request.

LECTURE 1: Part One

The Reform Movement and Restructuring Schools

Robert Chase
Vice President
National Education Association (NEA)
Washington, D.C.

If we are to meet the challenges of a rapidly changing society, we must move from the old industrial age mold of efficiently processing students to the dynamic demands of effectively educating students. Education must change in order to become as intellectually creative, as technologically innovative, and as dramatically evolving as the times in which we live.

To achieve this goal, we must address ourselves to the fundamentals of schooling — how teachers teach and how students learn. Changes in our economy, in the demographics of the school-age population, in family structures, and in the role of women in the work force have dramatically changed what our students need to learn and when they need to learn it.

Students must be able to think analytically and symbolically. They must be able to use higher cognitive skills. They must be prepared to become lifelong learners. Futurists tell us that young people today will probably change their careers on an average of four or five times in their life. So, they must be prepared to be self-starters, to ask pertinent questions, to challenge, and to work collaboratively. Every student certainly needs a sound and thorough education not only for their personal economic survival and prosperity, but also for that of our nation. It is our job, yours and mine, whether or not you are a teacher, to ensure and to provide the means by which every American child has the opportunity to have a true quality education.

In effective schools, staff have the latitude to define how a school is going to be run at the building level.

Children must have access to that opportunity early. Elementary schools have been the most painfully neglected in the reform of education. Each of us knows the absolute critical importance of a strong foundation. Only 18 percent of those who are eligible for Head Start programs are currently being served by these programs; only 40 percent of those who are eligible for programs that fall under Chapter One are being served. These are the students who are (1) growing in number and (2) are in the most need in the elementary and preschool level.

Schools must become creative forces capable of enlightening, exciting, and spurring intellectual development, creative genius and the capacity for compassion. This cannot be done the way the schools are currently run or if those of us who are involved in the work place are not part of the decision on how to run and how to change things. In effective schools, staff have the latitude and authority to determine curricula content, crack discipline codes, define school-wide objectives and priorities, and define how that school is going to be run at the building level. The National Education Association (NEA) has been doing something about this for the last few years, and I will share some of the things that we think have been successful.

In 1986, we began a program called Mastery in Learning. We have 26 individual schools across the country with a total of 23,000 students. In these buildings, everyone involved is determining how the school should operate and how it should be run. We have a partnership with IBM among these 26 school sites which enables the schools to communicate with each other via computer and to share experiences in what works and what does not. We have also involved the Regional Education Laboratories and higher education as resources to assist with the development of these programs.

Another project called the Learning Laboratories has identified four schools. We hope that there will be a school district in each one of our states that will become a learning laboratory. Memphis, Tennessee is one. In 1988, Memphis closed down the seven most troublesome schools in the city and reopened them a year later as democratically controlled school communities. Administrators and staff are selected through a process that involves the active participation of teachers, administrators, parents, and other concerned citizens. When people were asked to be involved and employed, far more applied than there were slots.

In a Minnesota school district, we created a teacher majority review panel to award grants directly to teachers for innovative approaches to restructure learning. In Iowa, we are eliminating central office monopoly on decisions about instruction and are creating new categories of teachers who will be responsible for building teacher teams to decide key curriculum and resource issues.

In Rhode Island, the whole community will be involved in the learning lab project. This project will use computers to link schools to parents, to educational resources within the city, and to the city government.

Reform is a slow process. When IBM decided to restructure its employee training — and IBM has a lot more money than public schools — they allowed themselves the luxury of time. They set out an eight-year project to redesign their training program.

I have been involved as a classroom teacher in many efforts to change schools. All too often

when a change occurs, if the results aren't quantifiable tomorrow, the change is thrown out and is never given an opportunity to succeed. Community activists must give us time. And we may fail once in a while. As a parent I fail once in a while with my child. In your business you fail once in a while, too. Schools must have the opportunity to be human and to make mistakes. Sometimes we don't try to do things differently because if we try and fail, it comes down on our heads and people say, "There go the public schools again. They are not doing the job they are supposed to do." It is going to mean risk taking by the school community, by parents, by the community at large, and by all levels of government. And, it is going to take a cooperative effort. We'll need steadfast support from you and the enriching experiences offered by a community in all areas — libraries, museums, recreation departments, galleries, industrial sites, government halls. We need to draw into the mainstream of education those special places in which words become pictures and in which what was previously only imagined takes the form of the real.

We hear that education must restructure, but restructuring must not be another phase. We don't need a phase now, we need an overhaul. For it to work decisionmakers need to say, "OK school staff and employees, you are part of this process, and we are not going to impose change on you. You know what our children need, and we have faith in you and your ability to do what's right for the children. We are going to give you the opportunity, the time, and the training to do what's necessary to meet the needs of every single one of those children, not the elite, not those who pass SAT's or the Iowa Test, or the California Achievement Tests, but every one of those children." I submit to you that if we don't do that, then we as a nation are doomed.

When change occurs, we may fail once in a while. Schools must have the opportunity to make mistakes.

LECTURE 1: Part Two

Goals for Education

The federal government's perspective on schooling in America today

Bonnie Guiton
Consumer Affairs Advisor to the President
The White House

Let me share a short fable with you. It is called the "Animal School". Once upon a time the animals decided that they must do something to meet the problems of the new world. So they organized a school. They adopted an activity curriculum consisting of running, swimming, climbing, and flying. To make it easier to administer the curriculum, all of the animals took all of the subjects. Now, the duck was excellent in swimming. In fact, he was better than his instructor but he made only passing grades in flying and was very poor in running. Because he was slow in running, he had to stay after school and also had to drop swimming in order to practice running. This was kept up until his poor little webbed feet were badly worn, and he dropped to average in swimming. But average was acceptable in school so nobody worried about that, except the duck. Now, the rabbit started at the top of the class in running but had a nervous breakdown because of so much make-up work in swimming. The squirrel was excellent in climbing until he became frustrated in the flying class, where his teacher made him start from the ground up instead of the treetop down. He also developed a charley horse from overexertion and then got a C in climbing and a D in running. The eagle was a problem child and was disciplined severely. In the climbing class, he beat all the others to the top of the tree, but insisted on using his own way to get there. At the end of the year, an abnormal eel who could swim exceedingly well and could also run, climb, and fly a little had the highest average and was valedictorian. The prairie dogs stayed out of school and fought the tax levy because the administration would not add digging and burrowing to the curriculum. They apprenticed their child to a badger and later joined the gophers and ground hogs to start a successful private school. Sounds familiar doesn't it? Well fortunately, that's not the case right now.

Education is a consumer issue, and we deserve a quality product. It is not a one-size-fits-all proposition.

In June 1987 when I joined the U.S. Department of Education, I had the impression that the federal government had the first and last say about the education of our children. My first lesson was to review the role of the federal government in education; here is a recap of that first lesson. The 10th Amendment to the Constitution provides that powers which are not delegated to the United States by the Constitution nor prohibited by the Constitution to the states are reserved for the states respectively and to the people. Because responsibility for education is not mentioned in the Constitution, it is legally reserved for the states which have the rights and the responsibility to organize and operate education systems as they deem appropriate — subject, of course, to constitutional guarantees of the rights and privileges of all U.S. citizens.

The Constitution provided for a federal presence by entrusting Congress with responsibility for the general welfare of the United States. On October 17, 1979, Congress determined that the establishment of a Department of Education was necessary to fulfill this responsibility. In establishing this department, the nation as a whole was voicing its belief that education is fundamental to the development of individual citizens and to our progress as a country.

The purposes of the Department of Education were stated as follows:

- to assure equal opportunity to education for everyone;
- to supplement and complement the efforts of states, the local school systems, and other instrumentalities of the states, the private sector, public and private educational institutions, community-based organizations, parents, and students to improve the quality of education;
- to encourage greater parental and community involvement in federal education programs;
- to provide research, evaluation and a network for sharing information about improving education;
- to improve coordination of federal education programs; and
- to improve the management and efficiency of federal education activities, especially with respect to federal allocation appropriations and streamlining the oversight of federal funding programs; and
- to increase the accountability of federal education programs to the President, Congress, and the public.

Congress declared, however, that this new law in no way increased the authority of the federal government over education, nor did it diminish responsibility for education which is reserved for the states and the local school systems. In fact, it has been stated that the fundamental mission of the Department of Education should be to assist education in the national interest but without interference in the fundamental responsibilities of the states and local agencies.

It is against this background that President Bush's call for an education summit was so significant. When I became the President's Special

Advisor for Consumer Affairs, he told me that education is a consumer issue. We all pay for the public education system whether or not we have a child in the public schools, and we deserve a reasonable return on our investment and a quality product. Managing education as a consumer issue is how we will get quality. By using the competitive forces in our free market systems, we can further induce our schools to excel. The immediate outcomes of the summit are to manage education as a consumer issue, to recognize that education is not a one-size-fits-all proposition, and to allow creativity and flexibility and at the same time ensure overall improvement in the quality of education.

At the education summit the President and Governors agreed, for the first time in our nation's history, to develop a national consensus on education goals. Commitment to achieving national goals in education will enable the Governors to coordinate their efforts and resources to improve the quality of education while, at the same time, maximizing flexibility at the local level. The search for ways to meet these goals should spark innovation in restructuring the schools, innovation in teaching methodologies, and hopefully, in curriculum development so that we can reach those students who have been turned off by education.

I would have been labeled a student at risk if we had used that term when I was a child. I had all the things working against me that we say are working against our children today. My father skipped the day I was born and my mother raised me. She was an alcoholic. There wasn't a lot of work for her and we were on welfare. I was brought up in an environment that said that I should fail, as so many of our children are expected to do these days because we place these labels on them. What helped me was that someone decided that education in its traditional form was not going to work for me. In my junior and senior high school years I was more interested in survival. I needed a job and a skill. I was taken out of some classes and put into vocational-technical education classes. I learned how to type — my first semester I typed 84 words a minute. They took me out of the class and put me into the vice principal's office; then I knew that I could make a living. I couldn't afford to go to college straight out of high school. My grades were abominable. I was 30 years old before I started a college education.

We have to start recognizing that our children are talented and gifted in different ways so that they will all believe they have something to offer. **Good management is necessary,** management that is responsive to an **open and equitable process for defining attainable goals**, and a process that **involves teachers, parents, administrators, school board members, elected officials, business and labor groups, and the public at large**. Each of these groups has the right and the responsibility to suggest measures that will increase the return from their investment in public education.

The President and the governors have reached a broad consensus on six national education goals that, if achieved, will help guarantee Americans international competitiveness. By the year 2000:

- All children in America will start school ready to learn.
- The high school graduation rate will increase to at least 90 percent.

- American students will leave grades four, eight, and twelve having demonstrated competency in challenging subject matter including English, mathematics, science, history, and geography.

- U.S. students will be first in the world in science and mathematics achievement.

- Every adult American will be literate and will possess the knowledge and skills necessary to compete in a global economy and exercise the rights and responsibilities of citizenship.

- Every school in American will be free of drugs and violence and will offer a disciplined environment conducive to learning.

The summit also addressed the **targeting of resources** and agreed on steps that will increase state and local flexibility in using federal funds in return for firm commitments to improve levels of education and skills training. The question is: Will it make a difference? Can we do this without massive infusions of federal funds? The answer is yes, we can if we work together. Will we need more? Yes, we probably will. But money is not the only factor. Today the federal government's portion of the educational funds is only 7 cents, and at no time has it been more than 10 cents of every dollar. As a consumer issue, management of education mandates restructuring in some fashion. Parental choice is one thrust towards restructuring schools.

Choice programs already exist in many districts that either allow open enrollment, or have magnet schools, or have policies to increase parental control. In Richmond, California, the Richmond Unified School District implemented what it called a System of Choice. The district has 50 schools, 30,000 students and 2,500 employees, 1,700 of whom are certified. In terms of demographics black students make up the majority with 35 percent, followed by white at 33 percent, Hispanics at 13 percent and Asian Americans at 11 percent. The district is not wealthy. It relies on a strong working class. Before a system of choice was implemented, in the 1987-88 academic year the dropout rate was 35 percent, student suspension days totaled 27,000 in one school year, the system was 4.2 million in the red, and parents had no faith in the system or in their ability to change it. Since the System of Choice was implemented, 46 schools out of 50 have converted to the new system. The California Achievement Test scores have risen from 11 points in the third grade to 26 points in the eighth grade, and they were up in every grade. Suspension has been cut by two-thirds, unexcused absences are down, enrollment figures are up — including regaining students from private schools — and attendance at PTA meetings has been as high as 300.

How did this come about? It came about through the effort of superintendent William Morse. **Morse began with parental involvement**. He had a series of fireside chats, about 93 of them during the first year, to get parents interested, to hear their ideas and to solicit their support. He also worked with the state of California Department of Education to **gain flexibility in state guidelines for funding**. No federal funds were used. Most importantly, he asked for the **help and support of the district's teachers and administrators especially in developing, writing, and implementing curricula for each of**

the system's learning programs. During this past summer he has had over 200 teachers working on new curricula for the programs. He has said that the principals have been key to the system.

Choice is based on **types of curriculum**. Morse insisted that all schools would be brought up to par, that they would all be good schools, but that they would have different focuses, because children learn differently and have different interests. Now there are schools of the **performing arts**, schools of **math and science**, and **schools of international studies,** and the parents are actively involved in where their children go. While each of the 46 schools **teaches a core curriculum**, parents may send their children to a school focused on a variety of areas. They may select classical studies or future studies or applied art or the Montessori method. The Richmond Unified School District exemplifies choice that is based on a belief that all children have special talents and skills but they learn in different ways; that all parents be actively involved in their children's education; that all schools must first be brought up to par so that the decision is not between good and bad schools but between different curricula and different emphases.

Choice is but one thread woven into a comprehensive and integrated education policy. At the summit a commitment to restructuring encompassed the following:

- a result-based system of accountability;
- transferral of authority in decisionmaking responsibility directly to schools;
- a rigorous program of instruction;
- incentives for teachers to reach their full potential; and
- active and sustained parental and business community involvement.

As our nation's education system is restructured, I believe a useful model can be found in American museums.

The American education system is unique in that it allows us to pursue further education at any age for career advancement or change. Likewise, museums provide the opportunity to learn at any stage in life and they cater to interests which can dramatically change over time. But while America's schools are just beginning to develop programs that serve a diverse range of individual needs, museums have long been devoted to developing programs for a wide variety of interests and audiences. Partnerships with local schools are among these programs, and I know that The National Learning Center at Capital Children's Museum is involved in such partnerships. In fact, The National Learning Center is a leader in its direct involvement with the school system right here in Washington, D.C.

Indeed, the programs developed by TNLC prove that museums make a vital contribution to American education, and by offering great choices and learning experiences to students of all ages, they increase the returns on our investment in education.

As our nation's education system is restructured, a useful model can be found in American museums which provide the opportunity to learn at any stage in life and which cater to interests that change dramatically over time.

LECTURE 2

Teaching Thinking Skills

David Perkins
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Harvard University

Understanding what learning is and the implications for classroom practice

A revolution is taking place today in our notions about learning and the nature of the learning process that has its basis in contemporary studies by educators, philosophers, and psychologists. We badly need this revolution because, when we look at the world of schools and learning, we don't see what we have been striving for with our teaching: the generative use of knowledge.

National reports and assessments of education have shown that some students are having profound problems with literacy and basic computation skills. However, things get really discouraging when we consider the generative use of that knowledge: very few students use the arithmetic skills they learned in school. Once outside of school, they don't tend to think much about what the morning newspaper says, if they read it at all, and they certainly don't connect the news to what they have been studying in social studies. Students don't think in terms of the principles that they've learned or of analogies about the cases and situations that they have heard about in school.

The current reductive form of education is giving students basic knowledge but not generative skills. Much of this knowledge is qualified by some psychologists as inert: it is stored in the attic of the mind, gathering dust. The knowledge is there if the teacher presses the button, if for example you give the student a test with multiple choice questions. But, the knowledge and skills do not function actively in problem solving, creative thinking, or critical thinking either in school or in everyday life.

Kids must reflect on their own learning process, "bootstrapping" themselves into more awareness in what might be called "mental management".

Educational Practices

At the center of much educational practice is a talent-view and a knowledge-view of learning, with the thinking-centered view floating out in the periphery.

Talent-centered educational practices are organized around the notion that different students have different levels of ability and that the educational system basically serves each according to his or her capacity — which you can't do much about. Students are viewed as cars with different-sized gas tanks. That is what education is about; you fill them up. A kid in school drives up and says, "Fill 'er up." We take the child's level of ability and service it. It's a noble quest on the part of any education system to try to serve everyone; nonetheless, talent is taken as a given.

Other education practices are knowledge-centered: the teacher provides knowledge and drills skills hoping that the student will acquire that knowledge base and become culturally literate. Although it is important to have those skills and that knowledge, education should be more thinking-centered.

An example of thought-centered education occurred recently in Massachusetts. Cathy is a fourth grader in the Boston school system, where her teacher is exploring the use of a program designed to integrate the cultivation of a child's thinking with the learning of subject matter. The topic was the Boston Tea Party, and the children had to discuss what the colonists, who were concerned about the Tea Tax, would do when a shipment of tea came in. Using a decisionmaking process, the teacher asked the children some straightforward questions about options. What could you do in this situation? What are the pros and cons of different actions? How do these pros and cons balance off against each other? The students were thinking about what the colonists felt, what the factors were, what was safe to do, and what wasn't safe to do in the context of the Boston Tea Party.

At first, the students kidded around and made all sorts of silly suggestions. The teacher was patient, however, and gradually they got more serious. Some real options were suggested, and the students thought about pros and cons in the context of the event.

At the end of this project, the students were asked to reflect upon the process itself. Cathy put up her hand and said, "You know, there are two things that I don't think are very good here. One is that, at the beginning of all of this, we were really messing up. We were giving these silly answers and they weren't getting us anywhere. We didn't do anything about it. You sort of let us mess around and screw up. I think maybe it would have been good to take us in hand a little more."

Actually, maybe it's better that the children themselves recognized the problem instead of the teacher's taking them in hand. However, the important point is that this is a classroom where children are thinking about and exploring the subject matter they are learning. By the time the session was over, they were engaged not just in thinking about the subject matter, but also about their own thinking, their own group process, and how it might go better. Now, that last part is terribly important. The kids were reflecting on their own process and "bootstrapping" themselves into more awareness, more consciousness about what might be called "mental management".

The Levers of Learning

But there is another dimension to learning, and it is a matter of asking "Why?" What are the true "levers" of learning — the things that push it along? How are those levers of learning organized, and where are they?

The most simplistic view of learning is that the "lever of learning" is a person's talent: the level of IQ or particular skills provide the structure of that lever and gives the child the learning power. The "standard theory" holds that the leverage that pushes a learning process lies in the efficiencies and organization of the neurological system and in the individual's head. To examine this theory, let's talk about knowledge and then intelligence.

There is an enormous amount of literature that says that learning, particularly academic learning, is highly correlated with IQ. Others maintain that you learn through the knowledge that you have already acquired and that having that knowledge levers ahead your learning all the more. For example, the single most predictive measure of your advance in a subject is how much you already know about it. As E.B. Hirsch would argue, if only we can equip people so they can know bits and pieces about many things, then they will have a lever to help them encode knowledge. There is a basis for both of those stances. However, in my opinion, they present a narrow picture of learning.

There are three kinds of intelligence in the broadest sense:

- Neural intelligence
- Experiential intelligence
- Reflective intelligence

Neural intelligence is, more or less, IQ, or crystallizing fluid intelligence. Experiential intelligence is what you learn, what you acquire by working through things and by having a job. Reflective intelligence is cognitive and strategic: it has to do with keeping systematic track of what you are doing, with asking yourself powerful questions like what are my choices or how can I relate this new knowledge to stuff I already know.

- Neural intelligence is the stuff of a talent-centered style of education;
- Experiential intelligence is the stuff of knowledge-centered education; and
- Reflective intelligence is the stuff of thinking-centered education.

If you want to talk about causal factors, it's clear that neural intelligence has a strong influence on how well people think and learn. Some people would say that neural intelligence is the only important kind, but research shows us that just isn't the case, that experience of the world and knowledge about it, including the world of academic subject matter and the world of "real life," are enormously influential in effective thinking and doing. In fact, for the short term, it's the most important single thing. Recent research has made that clearer and clearer. If you use the statistical technique called Path Analysis and fold experience into the equation, you will find that the most direct predictor of performance is experiential and knowledge-base, rather than the IQ, which is a better long-term predictor.

Reflective intelligence has to do with keeping track of what you are doing, with asking yourself powerful questions.

Reflective intelligence has a lot of structure: a microstructure, a macrostructure, and a metastructure which function together.

The third part of the picture is reflective intelligence, which is a major influence on human performance. It determines the extent to which people think about what they're doing, actively problem solve, and actively process information.

Some of the most interesting pieces of evidence about reflective intelligence concern learning disabled students who display very poor memory skills. Experiments show that when you teach marginally learning disabled kids memory strategies, their performance level on memory tasks rises almost to the level of normal students. This enormous gap is bridged quickly because they are now functioning strategically; they have learned a better way to use their neural and experiential intelligence.

Let's get back to the levers of learning. One lever is neural, another is experiential — a lever of knowledge — and the third is the reflective lever, the use of reflective intelligence to organize, direct, and systematize learning and thinking processes. That lever is particularly important because it is the lever of opportunity. The neural component of intelligence, research suggests, cannot be influenced very much. It really is like inborn talent. As for the experiential side of intelligence, we already do a good deal to expose students to knowledge. And as research shows, the acquisition of experiential intelligence — that is to say knowledge-based details, facts, routines — is a slow process; it takes years to build up competency that way.

However, we aren't doing much about reflective intelligence right now, and evidence shows that in months or a few years it can have a considerable influence on students' competency. So, not only is reflective intelligence a lever of learning, it is also the lever of opportunity, and the one we can lean on most easily.

How are these levers of learning organized? Some hold the provocative view that there are intelligences of several sorts (including linguistic, mathematical, and musical) partially neurologically based, and a problem in education is that teachers do not cultivate them. Others think that education is too fixated on linguistic and logical/mathematical intelligences.

Psychology has discovered that experiential intelligence is much richer, more important and complex than we might have thought. Research has disclosed that a person's cognitive database for a subject like history is much more than a bundle of little tiny facts; it's full of something that has complex structures with multiple sides that allow various kinds of problem solving. For example, your database in economics consists not only of some formulas and some facts about particular cases, but general notions like the law of supply and demand as well as a lot of half general notions gleaned from classic cases. You think with the big thick bundle of stuff involving thousands of schematics. This is why mastering subject matter to a high level is so glacial. And this enormous amount of stuff to be learned is not in textbooks; it's part of what you discover experientially.

The structure of reflective intelligence is different from the other two. The easy view states that reflective intelligence is being an enthusiastic thinker, getting in there and solving problems, thinking about what you are doing. Actually, reflective intelligence has quite a lot of structure to it: there is a microstructure, a macrostructure, and a metastructure of reflective intelligence.

At the "micro" level, thoughtful people search for options. They consider alternative solutions, try to find what the problem really is, and try to get a holistic sense of the situation. But that's not all there is to it.

If you look at how intelligent, reflective people behave, you find that, after making all those little moves, they weave them together in tapestries and use them for a form of rough sequencing that directs itself toward an intelligent resolution in a decisionmaking situation. The same thing is true when a student is trying to understand a difficult text or concept. Reflective people think about how they are thinking; they pay attention to how they are doing and direct their thinking. After they are done, they ask themselves how it went and how they can do better next time. That is the metalevel of organization in reflective intelligence.

Cathy and her fellow students were engaged in all those levels. They looked for options; that's a micromove. They were engaged in the entire macrostructure, the entire process of decisionmaking, and during the project, they were reflecting on their thinking. The simplistic view of Cathy's participation is that she is just a thoughtful person. The contrasting view is that there is some structure to her thinking, some multiple layers, and that we should pay attention to them. There are many programs that cultivate children's thinking. However, they only pay attention to one level, and that is unfortunate because the three levels function together.

Yet, there is still a different concept we need to consider: distributed intelligence. There are three kinds of distributed intelligence:

- socially distributed;
- physically distributed; and
- symbolically distributed.

Socially distributed intelligence involves effective thinking processes that quite characteristically occur in group, rather than in solo settings. For instance, good settings of collaborative learning result in a ricochet of ideas from one person to another and a spiraling of ideas so that the group thinks better than the individual people in it. One of the simplest and most important factors about a group setting for reflective learning is that it forces people to articulate their thoughts. By so doing, they reveal patterns of thinking and allow others to learn about thinking. The process is quite spontaneous in a well-designed collaborative setting.

Reflective thinking processes occur in a group rather than an individual; they are a part of a culture of thinking and learning that involves multiple individuals with various talents. One prominent theorist, Soviet developmental psychologist Lev Vygotsky, made this tenet the sole basis of his perspective: although thoughtfulness and reflection is acquired, he basically said it is assimilated and internalized from your interactions with others.

Intelligence is also distributed physically. That means we do not just function in our heads, we can mark down things that we are thinking about. Word processors, pencils, cameras — these devices all support the thinking process. If you can work with paper and pencil, then you can solve some problems that you can't tackle otherwise.

One of the most fundamental facts of the psychology of the mind is short-term memory. We can only hold about seven chunks of information in our minds at one time. Actually, in active problem solving situations, the number seems to be three or four chunks of information at a time rather than seven — unless we are using paper and pencil. Then we can keep track of more than a dozen things at once by jotting them down and looking back and forth rapidly to connect things.

There is distributed intelligence. In socially distributed intelligence ideas ricochet from person to person so that the group thinks better than the individuals in it.

In physically distributed intelligence you think on paper, in quick notes, marginal jotting, concept maps — things schools do not cultivate.

In symbolically distributed intelligence you think in algebra, in images, in pro and con lists, in diagrams, in gesture. Most thinking needs the support of symbols.

The simple act of using paper and pencil opens up the capacity of immediate memory, of "working memory', as it's called. That is important because an abundance of research shows that a limited memory span is the primary reason why students cannot master many complex problems.

People think that learning is basically a head game. You do the routine stuff like arithmetic on paper, but understanding, working through ideas, conceptualizing, explaining ideas — that you do in your head. Actually, a great deal of valuable information processing occurs on paper, not in conventional essays but in more flexible formats like quick notes, marginal jotting, and concept maps. Of course, typical schools have hardly any courses that cultivate this kind of thinking on paper.

Finally, there is symbolic distribution. The point here is quite simple: you do things with symbols. We don't just think, we think in algebra, we think in images, we think in pro and con lists. It is important, therefore, that language and other forms of communication such as diagrams and gesture be cultivated because they can be vehicles of thought. Most thinking needs the support of symbolic vehicles of one sort or another.

A person's ability to function intelligently as an effective learner is distributive in character. It is not something that is just here; it involves as part of the process a whole flow of information that encompasses symbolic vehicles used by people for communicating and thinking. People function more intelligently if they are given the right kinds of social setting, physical setting, and symbolic support, symbolic facilities, and languages with which to think. And we can help people by creating these social, physical, and symbolic settings.

What does all this say about Cathy? Well, the simplistic view of Cathy's thinking would be that it's in her head; the more informed view would say that Cathy is part of the social setting that the teacher has set up in this classroom. The teacher and students are reacting with one another, and they are reflecting as a group.

As to the physical setting, there are posters around the classroom, physical things to support the thinking process, to make it visible in the classroom as symbols. Language is used, key words are used, and diagrams are used as symbolic vehicles to capture and record the thinking that the class and the teacher are doing.

Thinking-centered Learning

We could say that there is the neural tripod, the experiential tripod, and the reflective tripod. But I want to argue for a recentered system, for thoughtful learning, for thinking-centered learning.

There are two parts of the thinking-centered lever — the "business" end that actually moves the stone, and the handle at the end of the lever that you lean on to cause something to happen. Both ends of the lever are important. If you are talking about causes only, I think you are talking about a tripod.

However, we are not just talking about causes for educators; we are talking about levers. That means that we want to lean on our end of the lever to make something happen. Our end of the lever consists of instructional practices, ways of organizing things, what the classroom looks like, how we interact with our students, what exercises are done, whether we use collaborative learning.

When we consider our end of the lever, we will find that the thinking lever is the one that offers us the most play.

You can't do much about the neural side. The knowledge side is important to keep in motion, but it is glacial and tends to be inert. However, by making the learning of subject matter a thinking-centered process, one gains two advantages. On the one hand, children's thinking is activated; they become more savvy about the handling of their minds. On the other, the subject matter is mastered actively, which works against the inert knowledge problem. To put it succinctly: "Thinking to learn and learning to think." That's why it's not enough to say that thinking is a tripod. We must put thinking-centered learning at the forefront of instruction.

We can help people think by creating social, physical, and symbolic settings.

For educators, instructional practices — what exercises are done, whether we use collaborative learning — offer us the most leverage over learning.

LECTURE 3

Situated Learning

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A discussion of research differentiating how children think in school from how they think in "real life"

We are beginning to look at theories of how the human mind works and actually to consider the notion of commonsense reasoning, a notion that we have fundamentally overlooked in virtually all current theories of how the mind works. The topic for this presentation, situated learning — learning by doing, learning in context — suggests steps toward a new theory of knowledge and how it relates to learning.

Two years ago in Washington, D.C., Lauren Resnick, who is a professor at the Learning Research Development Center in Pittsburgh and past-President of the American Education Research Association, gave her Presidential Address. She wanted to dwell on something that actually has been overlooked. She wanted to focus on what the fundamental differences are in the way we characterize in-school learning versus out-of-school learning, versus street learning, versus learning in the work place, and so on.

Dr. Resnick laid out the following four fundamental dimensions:

1. Individual thinking versus collaborative thinking — the ability to work together:

The first dimension has to do with the notion that in school (classical school) almost all work is focused on individual work, individual problem solving, and what we might call individual cognition (thinking). In fact, if children don't engage in "individual" work they are often thought of as cheating. And yet, what happens when you get out of school? In the work place, almost everything

In schools almost everything is focused on individual work; in the work place almost everything happens collaboratively.

In school we think without actually doing; in the work place everything is in how we do something.

happens collaboratively. When you want to get anything done in the street, in the work place, anywhere you want to be, your ability to enlist people to work with you is probably the single biggest factor which will assist you. Yet, the school system has almost ruled that illegal.

2. Abstract thinking versus concrete thinking — doing, use of tools

The second dimension has to do with pure mentation (abstract thinking) versus total manipulation (doing). In the school systems, our preoccupation is with abstract learning and thinking without actually doing. On the other hand, what happens when you get into the work place or onto the street? Everything you learn is evident in how you do something. How do you use the tools around you? How do the concepts you learn become tools to make things happen — not pure principles, but rather actual activities?

3. Use of symbols versus reasoning

The third dimension has to do with the notion of looking at how you learn high school algebra, geometry, physics and other sciences. The focus is on learning how to manipulate symbols. One of the first things you learn in doing science or doing anything in the work place or in graduate schools is that symbols don't mean that much. First, you learn how to look through the symbols into the work, how to ask: What do the symbols reflect? You reason not particularly with the symbols, but with what the symbols are about. That's where you get your intuitions about how to manipulate the formal symbols of mathematics. Physicists and mathematicians alike do not engage in pure symbol manipulation. In fact, they deal with and manipulate the entities, either concrete or abstract entities, that sit behind those symbols. They reason about stuff in the world.

4. General learning versus specific reasoning — concrete reasoning with stories

The fourth dimension has to do with reasoning with stories. In schools, we have been taught to search for abstractions because abstract knowledge has the powerful property of applying to all situations. Maybe that idea is fundamentally wrong. Maybe, in fact, the way you reason in the world, in the work place, or in any situation is with stories. If you think about it, our culture has been passed down to us in the form of folktales. Folktales, not abstract thoughts, carry tiny stories that help us understand the world. What makes a play a great play? Why are Shakespeare's plays still around? It's because we can take any one particular out of those plays and apply it in a new situation and see something new in the situation and in the play. Mind, play and situation come together to coproduce a new understanding of the play and of the situation. That probably is where the real generality lies. In school, the theories underlying what is to be taught and how the human mind really works turn on the notion of abstract thought, not on how the concrete carries the general.

Summary Chart

There are interesting differences when you look at how typical in-school learning compares to out-of-school learning. The following chart summarizes those differences.

IN-SCHOOL LEARNING	OUT-OF-SCHOOL LEARNING (Work, Home, Community)
Individual Learning	Work Cooperatively
Abstract Thinking (Pure Mentation)	Concrete Thinking — Doing, Use of Tools
Symbol Manipulation (i.e. Math Formulas)	Look Beyond Symbols — Reasoning—What They Reflect
General Learning— Abstract Thought	Specific Reasoning—Concrete Reasoning with Stories

This chart challenges most of our theories about knowledge. It challenges what we accept as in-school learning as opposed to what we do in real life. For example, compare a student sitting in a school room thinking abstractly about a science concept versus the "real doing" of science. Crick and Watson discovered the DNA molecule by working together, by constructing practically out of tinker toys the model of DNA that explains how life promulgates — not reasoning abstractly but reasoning concretely, cooperatively, in real time. There is quite a difference between these two images.

We are rethinking how the human mind works, how we think, and what forms expertise. This is bringing about new types of learning environments. Snow skiing is an example of using a new way of teaching with new tools. Twenty years ago, it took most of us two years of intensive work to learn how to ski. Today it takes approximately two weeks, if you are slow, two or three days if you are fast. What is going on? How have we been able to accelerate the acquisition of a skill as complicated as skiing that rapidly? Today, shorter skies and a more direct approach to teaching parallel skiing are used. I find that example very suggestive because it gives us a new set of ideas about how technology improves the learning experience.

We are not taught in school to think and solve problems the way we do in real life. The following stories are examples:

- **Story One** — The first example has to do with counting. We all do it, we did it, and sometimes we still do it. We count by somehow using our hands as a crutch. In fact, I can tell you some of the most elaborate techniques for counting money with incredible speed is on racetracks, which is where I first started to notice the ways to use crutches to count money. Between the time that the bell rang and the race was over, we had to count all the money, compute all the odds and be ready to pay off at the next moment. You have to count that money fast. I tell you none of the techniques we learn in school work, but counting on our hands does. Now, the use of the hands for counting seems simple enough, but maybe not particularly profound.

- **Story Two** — In school, we are taught that if you want to compare the price of two kinds of cheese, you divide the weight into the price to get the price per pound and know which is the best buy. Researchers observing actual

In schools we are taught to search for abstractions; in the world we reason with stories.

We are not taught in school to think and solve problems the way we do in real life.

In real life the ability to make sense out of something makes an expert an expert.

customers found that in real life people find a piece of each kind of cheese that is about the same size. Then they read off the price and select the one with the lower price. The customers do not use division to solve the problem.

- **Story Three** — The third story is called the "Weight Watcher's Problem". The setting is in the home of a man making dinner for three people. The recipe he used calls for 2/3 of a cup of cottage cheese and serves four people. How much cottage cheese does he need for three servings. The "in school" solution is to multiply 2/3 by 3/4; the answer is 1/2 cup. The solution "in real life" is to pour the cottage cheese into a 2/3 cup measure, flip it upside down on a table, empty it out, shape it into a round patty, cut it into quarters, and use three of them.

The real life solutions in these stories made use of objects in the physical world to do some of the work and avoid making an error. They did not just use the abstract symbols of divide and multiply. They used what seemed like the "natural way" to solve the problem.

In school we are given well-defined problems to solve with well-defined goals. The goals are usually getting the answer correct and getting good grades. However, in real life problems are not well defined, they are the result of an activity or situation. It is the ability to make sense out of something that makes an expert an expert, not his or her ability to grind through a formal problem.

If we want students who have the ability to use abstract and general concepts in the real world, they should be given authentic real problems to solve. Students need to be motivated to learn by understanding why they are learning a concept and how it will be used. It has to make sense in the student's own mind.

A typical story is the group of A students in a first-year physics course who were not able to solve a practical problem — predicting how a pea blown through a spitball system would behave. These students had a theoretical model of classical mechanics that had never seen the light of day in the real world.

Knowledge is not a substance which is simply poured into a student's head. It is a tool with which to do things. Learning is a cooperative sense-making activity which provides us with a set of eyeglasses that we use to understand and to make the world work.

LECTURE 4

The Mediated Learning Experience

Dr. Reuven Feuerstein
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Mediated learning and cognitive modifiability discussed by the renowned "father" of the theory of mediated learning

In recent years, the issues around the role of intelligence in human adaptability have been widely discussed. In addition, there has been considerable investment in both educators and educational systems and in intervention programs oriented toward changing human intelligence.

- How can we explain this interest in the development of intelligence today? Is the role of intelligence so vital for human adaptability that it warrants this type of investment?
- If the development of intelligence is so important, to what extent do we need to consider modifying it or changing it? And, if it is possible to affect intelligence through specific intervention, what are the best ways to achieve those changes?

For a long time, intelligence was not considered the most important determinant of development, behavior, and adaptations in humans. Dynamic psychology ascribed much more importance to emotions, activity, and motivation. Even today, people dealing with young children speak more about how to develop their concept of self, their self confidence, and their motivation — and little about how to develop their intelligence. Psychoanalytic approaches, however, show that many people with an intact intelligence act like children, and the question arises: what roles does intelligence play in the adaptation of human behavior?

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Psychologist Jean Piaget has noted the crucial role of intelligence in the adaptation of the individual and the formation of emotions. A good cognitive basis is necessary to develop higher levels of emotion and to generate different types of motivation. In other words, to be motivated, you have to know what kinds of situations affect you.

Adaptation is a response to changes in the internal or external environment. Today, individuals are increasingly called upon to adapt intelligence, and these changes are strongly related to intelligence and cognitive processes. The burden we lay on these processes to perceive events that happen inside and outside of us, our capacity to understand the changes, and the relationship between certain conditions and the changes they produce are of the highest importance.

Freud describes two types of defensive responses:

- **The alloplastic defense** is used when we attack the source of danger. For example, we have learned to defend ourselves from environmental changes by altering the environment.

- **The autoplastic defense** is used when we produce adaptive changes within ourselves. In human beings, autoplasticity is mainly reflected by a change in cognitive processes, by adapting and becoming more defined as a result of experiences.

A flexible person changes his/her mind following a given experience and uses each event to develop a more efficient way of handling new experiences. Years ago, individuals were less adaptable because they lived in familiar, slow changing environments that equipped them with the necessary tools for life. Nowadays, one of the most important goals of our education system is to render the individual more plastic, more able to benefit and become modified through exposure to experiences.

Is it possible to modify intelligence? In the past, little emphasis was put on the development of intelligence because it was considered an immutable, unchangeable entity determined by heredity. Today, we believe that intelligence can be structurally modified — that human beings are highly modifiable.

Concepts of Modifiability

The concept of modifiability relates to the structure of the mind, to ways people interact with environments, and to the plasticity of human beings. The theory holds first that **humans are modifiable regardless of the reasons for their condition**, whether external and environmental or internal, hereditary, genetic, or chromosomal, human intelligence can be modified — if the necessary conditions for change are instituted.

Second, **humans are modifiable regardless of age**. Some scientists believe that exposure to stimuli can affect an individual's capacity meaningfully; however, they also believe that this can only take place within a limited time. Therefore, children must be offered types of intervention early in life so their brain, which is in the process of development, will be affected. Head Start and other such activities were instituted based on the concept that intelligence develops through experience and environment — but only up to a

given time. Today, some psychologists think that development is not a critical-period phenomenon, that it spans over life, and that modifiability is not age-dependent. Older people now continue their education and attain a higher level of functioning.

Third, **humans are modifiable regardless of condition**. Many people are denied the right to develop because we consider their condition too severe to be affected by intervention. But, the capacity for human beings to become modified is not necessarily limited, even though it may require different types of interventions. Millions of people are uneducated because we do not try to reach their capabilities.

We know from the history of the human race that individuals can modify themselves in a meaningful manner during their lives. What is it that makes humans so flexible?

The Mediated Learning Experience

The theory of the Mediated Learning Experience plays two roles. It explains the phenomenon of modifiability, and it suggests how to increase human modifiability.

The early learning theorists explained development as a result of stimuli — the whole world that impinges on the organism — and response — the way an organism responds to stimuli and development — a human being's intelligence and behavior are affected by the relation between the stimuli and the response. This is the behavioristic theory of human development.

The Piagetian theory claims that the organism, which has characteristics and stages of development, determines the nature of the stimuli, how they will be perceived, and the nature of the response. Basically, these two theories, stimuli-response or stimuli-organism-response, try to account for the development of a human being through the interaction between direct stimulation and direct response. This interaction is also found in lower animals; but they do not develop higher processes.

To what extent are our higher mental processes, our capacity to take whatever we have learned and turn it into sources of new learning, just the outcome of being exposed to stimuli? Furthermore, is direct exposure to stimuli enough to develop higher mental processes, abstract categories of thinking, and superordinate types of mental operations?

The theory of mediated learning experience proposes the existence of two forms of interaction of the human organism with the world: one in which the organism is exposed directly to stimuli and responds in a direct way to them, and the second, which is typical only for human beings, in which a mediator interposes himself between the organism and the stimuli, thereby changing the perceived stimuli. This mediator creates in the "mediatee" a whole set of ways of looking at, selecting, and scheduling perceptions that is distinctly different from when things are perceived directly.

We believe that the capacity to learn — the flexibility of human beings, their capacity to benefit from experience and to remold following exposure to stimuli — comes from this mediated experience. Individuals who have not been exposed to mediated learning experiences, regardless of how much stimulation they were exposed to and how rich the experiences, will not be

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The mediator makes an interaction animated, efficient, and effective; bridges from the particular stimulus to the general; and endows the stimuli with emotion.

modified. An individual who has not been exposed or did not benefit from his/her exposure to experiences is culturally deprived.

A mediator imposes himself between the stimuli and the organism, changes the stimuli, and causes the individual to perceive the stimuli as the mediator intends. The mediator creates a whole set of dispositions, attitudes, modes of perceptions, ways of looking at things, ways of selecting and scheduling the things that are perceived. It is very different from what the individual perceives in a direct way. The mediator creates a disposition to learn, creates flexibility, and enables an individual to be affected by the learning process which is occurring through direct exposure to stimuli.

You can mediate an individual in many ways and in any manner. Mediated learning experiences may use a variety of languages, interaction, objects, or events. The mother of a young child focuses behavior just by looking at her child, searching for eye gaze, and establishing eye contact for a long period, clearly interacting with the other person. She has a need to see her child; the child responds to her and even turns around to see the mother. This reaction is not apparent in many youngsters who have been deprived of mediated learning experiences, particularly those who live in orphanages where children have no permanent objects to look at and so develop a sweeping kind of perception that prevents them from focusing their attention.

Mediated learning experiences can start at the earliest stage in life, but they must be marked by intention. The mediator intends to make a child observe, to make the child react in a particular way and, by virtue of this intention, does a variety of things. Intentionality transforms the three partners involved in the interaction, notably: the stimuli, the mediatee, and the mediator. All will undergo changes in order to make an interaction animated, efficient, and effective.

If I want the child to learn something, I will talk so that the child has confidence in me and accepts what I have to say. This style of instruction is different from usual teaching situations because my intentions change the three partners of interaction: the stimuli that the child perceives; the child, who has to perceive what I want; and the mediator (me) who attempts to manipulate things so that the child will see them and learn.

The mediator doesn't limit interaction to the specific behavior or event that elicits the child's attention but goes beyond and bridges from the particular stimulus to the general. This is called transcendence. It is extremely important to the learner because it creates a tendency to attend to a wide array of situations and to develop an ever-expanding mode of thinking.

The mediator affects meaning by endowing the stimuli with emotion to ensure that the individual registers the event. If children are taught in a neutral way, they will not be interested. However, if the teacher charges the material with emotional and energetic value, the individual will learn.

Modifiability

These three elements of mediation — intent, meaning, and transcendent purpose — are responsible for the most important human characteristic: modifiability. There is nothing more stable in the human character than the capacity to change. Therefore, stability is changeability, and both are fostered by interaction with the help of mediators.

The structure of modifiability, which is strongly linked and explained by the mediated learning experience, has generated three applications, each of which constitutes a system:

- Dynamic assessment (Learning Potential Assessment Device);
- Intervention aiming at increasing modifiability (Instrumental Enrichment); and
- The shaping and modifying of environments.

Assessment — the Learning Potential Assessment Device

Today, we assess by a static measure, the IQ test. We give the individual a set of tasks at a given moment and under a given condition, and the responses to these tasks are considered predictive of how the person will respond in other situations to other tasks at other ages with other examiners. However, the IQ test does not truly reflect the individual.

We use a dynamic approach to assess an individual's capacity called the Learning Potential Assessment Device. It assesses not what a person is able to do at a given moment, but rather the individual's modifiability, or the potential to change.

The Learning Potential Assessment Device provides a profile of how a person changes. An individual is given a task first with no help and then with mediation and then without mediation (Test-Mediate-Test). Once the task is completed, the individual is offered opportunities to apply what has been learned to more complex situations. At first unable to do something alone, the individual can now adapt on a higher level. Not only are we able to say that the person is modifiable, but we have deeper insights into what will be the quality and quantity of intervention necessary to change the person's cognitive structure meaningfully.

The Learning Potential Assessment Device has been employed with thousands of people who had been doomed to a low level of functioning; it has meaningfully changed the course of their lives. Early in the 1950's, we used this method with mentally retarded children who came from various countries and who had a wide range of ways of functioning. We proved that they were accessible to change.

Instrumental Enrichment (IE)

Instrument Enrichment, a technique based on the theory of the mediated learning experience, is a set of exercises whose goal is to increase the individual's capacity to benefit from learning situations, i.e. learning to learn. The teacher analyzes deficient functions and looks for ways to attack and modify them. This 350-hour program is given only by properly trained teachers who use instrumental enrichment in the classroom over a period of months or years.

An Environment that Encourages Change

You have discovered that the individual is modifiable, you have even enhanced this modifiability by using instrumental enrichment. Is it enough? An individual with a high profile of modi-

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fiability who is placed in an environment where nobody expects him/her to change or to apply what has been learned will dwarf all his/her capacities. In order really to modify a person's capacities, you have to create an environment where change, development, and adaptation are needed for survival. Otherwise, an individual will not be likely to change.

Conclusions

We are failing in three areas:

- We do not investigate an individual's modifiability and think he/she cannot function because, at a given point, he or she does not function.
- We do not increase modifiability; instead we equip individuals with information that soon becomes obsolete.
- We create environments that do not encourage change. Many people give up in desperation. They don't believe they can have a better experience than the one given them daily.

Our theory of structural cognitive modifiability — the mediated learning experience — attempts to give human beings responsibility for modifying themselves, their environment, and their existence.

LECTURE 5

Literacy and Intrinsic Motivation

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The role of motivation in learning, the theory of flow state and its relevance to literacy

Mass literacy is not as easy to achieve as educational reformers had anticipated. To close the gap between the dismal reality and the golden future, many of today's researchers and practitioners are investing their energies in teaching methods modeled on computers and other rational means for processing information. These in turn are modeled on industrial production techniques and on military human systems design. The hope is that if we discover more and more rational ways of selecting, organizing, and conveying knowledge, children will learn more effectively.

Yet, it seems increasingly clear that the chief impediments to literacy are not rational. It is not that students cannot learn; it is that they do not want to. Computers do not suffer from motivational problems, humans do. We have not as yet found ways to program children so that they learn the way computers do. Unfortunately, cognitive science has not taken adequate notice of this fact; hence, the current cognitive emphasis on teaching is missing out on an essential component of what learning is.

If educators invested a fraction of the energy they now spend trying to transmit information in trying to stimulate the students' enjoyment of learning, we could achieve much better results. Literacy, numeracy, or indeed any other subject matter will be mastered more readily and more thoroughly when the student becomes able to derive intrinsic rewards from learning — that is, learn for the joy of learning not for the grade or some other "carrot". At present, however, lamentably few students believe that learning can be enjoyable.

The chief impediments to literacy are not that students cannot learn; it is that they do not want to. If educators tried to stimulate the students' enjoyment of learning, we could achieve much better results.

Computers follow logical steps as long as they are plugged in; people think logically only when they feel like it.

Today, in most technologically advanced countries, the lowest level of performance tends to be above the American average. The Japanese average is higher than that of the top 5 percent of American students enrolled in college preparatory courses. Given such facts, it is difficult to comprehend how the majority of young Americans can ever find jobs, and how they can figure out whether they are making or losing money.

To counteract these alarming trends, educational researchers and cognitive psychologists have been devising new models of the learning process, new methods of instruction, new teaching technologies. Textbooks are getting revised so that the information they contain is more clearly presented (in terms of the current fashionable theories); the latest advances in computers, data processing, and audiovisual equipment are harnessed to the task of delivering information to the recalcitrant students. However, this educational innovation seems to make few inroads into the inertia of learning. The shining kings who ride forth equipped with the latest weapons of cognitive technology return blackened and bruised, while the dragon of ignorance goes on peacefully slumbering in its cave.

The problem is that educational methods which work well under laboratory conditions often fail dismally in real life. It is dangerous to generalize from experimental performance of humans — of children especially — to what they will do at home. Confined in a psychologist's lab, children may learn a new way of doing math very fast just to impress the tester, or because they want to get out of there as soon as possible. But they may completely ignore the same material when it is presented to them in school.

Inferences about how children learn based on how computers work tend to be equally flawed. People are not like thinking machines in one important respect: whereas computers are built so that they will follow logical steps as long as they are plugged into the wall and the appropriate software gets booted up, people think logically **only when they feel like it**.

The major impediments to literacy — and learning in general — have little to do with the logic of how we present information; if anything, the aesthetics are more important. This is because the obstacles that stand in the way of learning are primarily motivational, not cognitive in nature.

Before the invention of the first symbol systems, the limit on how much information we could process and remember was set by the biological capacity of the central nervous system. When a person died, his or her laboriously acquired knowledge disappeared. Whatever useful knowledge a person learned had to be passed on by word of mouth, thus garbling the content and creating bottlenecks in communication. By removing knowledge from the fragile network of nerves, and carving it in bone and stone instead, our ancestors made it much more permanent and accessible.

Literacy is the ability to code and to decode information preserved in memory systems outside the brain. A person who is literate has access to the knowledge stored in a particular system. A mathematician knows a particular set of symbols; so does a Chinese poet, a chemist, a composer.

Thus, illiterates are not necessarily less knowledgeable, less smart, or less able than their literate counterparts. Rather, they are excluded

from access to information contained in a particular set of symbols. Whether or not this is a great handicap depends on the extent to which one must rely on such knowledge to function well in a particular society.

Despite the endless rhetoric about how the jobs of the year 2000 will need employees with much higher levels of literacy, it is not clear whether that is the case. It is true that most forecasts see computer system analysis and programming as the fastest growing occupations in the near future. But, numerically such high-tech jobs are dwarfed by the much more numerous openings anticipated in a variety of jobs that require fewer skills than farmers and skilled factory workers had a few generations ago. The greatest future demand in the labor market appears to be for armed guards, fast-food preparation personnel, truck drivers, sanitation workers, nurses' aides, and other relatively unspecialized tasks.

If this is true, and if a substantial proportion of our youth does not expect to benefit from acquiring high levels of literacy beyond what is needed to get a driver's license or to read the sports pages, then a strong incentive for learning is not operating. Moreover, this situation will not be remedied by improved teaching methods or new educational technology.

Many young people nowadays think it isn't sensible for them to learn too much because the social system will not reward their knowledge anyway and they can live very well without it. Let others worry about stuffing their heads with esoteric facts. Yet, if this attitude continues to spread, productivity will decrease to the point where the entire economy may collapse. If we don't want this to happen, it is imperative that we find ways to provide realistic motives for the acquisition of literacy by more young people.

This transition from literacy as a tool to literature as an end in itself seems to have taken place in similar ways in several cultures that had developed writing more or less autonomously, such as in the Near East, the Indus Valley, China, and Japan. The emergence of a more complex motive out of a more primitive requirement is not a rare event; in fact, it constitutes a constant trend in the cultural evolution of humankind.

If educators, instead of treating literacy as a tool, focused on the rewards intrinsic to literacy, they might get students interested enough in exploring the various domains of learning for the sake of what they can find there. When that happens, the teacher's task is done! Intrigued by the opportunities of the domain, most students will make sure to develop the skills they need to operate within it. Applying a model of intrinsic motivation to learning may make it possible to advance the cause of literacy beyond the point where technology and a mechanical rationality cease to be useful.

When people enjoy what they are doing, they report a characteristic experiential state that distinguishes the enjoyable moment from the rest of life. In other words, the phenomenon of enjoyment seems to be a human constant. When all the characteristics are present, we call this state of consciousness a flow experience. Consequently, we have called the theoretical model that describes intrinsically rewarding experiences the flow model.

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the rock, the sky, and the wind; the chess player merges with the field of forces on the board; the dancer cannot be told from the dance; the mathematician is so involved in her calculations that she forgets sleep and hunger; reading a good book "...you are a patient pool or cataract of concepts which the author has constructed...The will is at rest amid that moving like a gull asleep on the sea."

This intense involvement is only possible when a person feels that the challenges in the activity are more or less in balance with the person's ability to respond. When the challenges are relatively greater than the skills, there is a sense of frustration that eventually results in worry and then anxiety; in the opposite case, when one's skills are greater than what is possible to do, one feels progressively more bored.

A second and related characteristic of flow experiences is that people often describe themselves as having clear goals. A goal is necessary to get feedback on our actions, so that at any given moment we know how well we are doing in terms of the goal. A goal is not sought for itself; it is sought only because it makes the activity possible.

The anticipation of reading a book or solving a problem is enough to motivate the activity. If you have ever traveled in a car with a child who has just learned to read, you know what I mean: she will read aloud every sign along the way, delighted in the ability to turn abstracts into words and concepts. The task of the educator is to keep that delight alive by presenting goals that involve increasingly more complex challenges matched to the student's developing skills.

When a person finds a goal which presents a range of opportunities for action that matches his or her skills, attention becomes so concentrated on the activity that all irrelevant concerns tend to be excluded from awareness. This happens because we cannot process more than a limited range of information at the same time; hence, the perfect attentional focus of the athlete, the religious mystic, the artist, the climber hanging over the precipice from his fingertips, or the reader completely taken by the characters and plot of a novel.

When concentration is intense, one consequence is that we lose the sense of self-consciousness. Attention is so completely absorbed in the task that there is not enough left over to contemplate oneself.

Flow provides a sense of control even when a person is involved in dangerous activities such as spelunking, sky diving, or rock climbing. Because these activities are clearly demarcated and appropriate rules are identified, the participant is able to anticipate risks and minimize the unexpected. Besides, there is just too much to do to worry about failure.

A matching of challenges and skills, clear goals, and immediate feedback, resulting in a deep concentration that prevents worry and the intrusion of unwanted thoughts into consciousness, and a transcendence of the self are the universal characteristics associated with enjoyable activities. When these dimensions of experience are present, the activity becomes autotelic, or rewarding in itself.

It is important to note that what people enjoy the most in their lives is almost never something passive, like watching television or being entertained.

Basically, young people are influenced by adults who appear to enjoy what they do, and who promise to make the youth's life more enjoyable too. This is not such a bad yardstick — why should youths chose models who look miserable and who strive to impoverish their future? Remember, enjoyment is not a hedonistic goal; enjoyment is the energy that propels a person to higher levels of performance.

The word educate comes from the Latin word educare, "to lead out". This implies meeting youth wherever they are and taking into account their goals, interests, and skills. Only after contact is made and attention engaged is there hope that they shall willingly follow our lead.

Teresa Amabile, Professor of Psychology at Brandeis University, who has researched the matter extensively, concludes that there are four main ways the spontaneous interest of the child can be destroyed:

1. One is for adults to attempt to control the child's performance as much as possible, by imposing strict rules, procedures, time constraints, and so forth. The more the child's attention is drawn to external rules, the more difficult it becomes to experience the intrinsic rewards of flow.

2. The second way to kill interest is through emphasizing evaluation. Excessive concern for rewards or punishment distracts from the task at hand and disrupts the concentration necessary for sustaining flow.

3. Too much emphasis on competition has the same effect. The Latin roots of this word con petire, or "to seek together", contain the idea that people can best find out the limits of their ability by matching performance against other persons'. But, when attention shifts to winning rather than doing one's best, competition endangers flow.

4. The last prescription Amabile gives for disrupting intrinsic rewards is to make the person self-conscious. Because everyone's priority is to keep the self safe, whenever danger or ridicule threatens it, we lose concentration and focus attention on defending ourselves rather than on getting involved with the task.

Schools follow very closely Amabile's prescription of how to disrupt enjoyment. Formal education thrives on external controls, evaluation, competition, and self-consciousness. Yet, as long as this is so, it will be difficult for children to be motivated to learn spontaneously for the sake of learning.

Fortunately, many teachers intuitively know that the best way to achieve their goals is to enlist students' interest on their side. They do this by being sensitive to students' goals and desires, and thus they are able to state their teaching goals as meaningful challenges. They empower students to take control of their learning; they provide clear feedback to the students' efforts without threatening their egos and without making them self-conscious. They help students concentrate

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There are four ways to destroy spontaneous interest: impose rules, procedures, and time constraints; emphasize evaluation; emphasize competition; and make the person self-conscious. Schools follow this prescription closely.

and get immersed in the symbolic world of subject matter. As a result, good teachers still turn out children who enjoy learning and who will continue to face the world with curiosity and interest.

There are two main ways that children's motivation to master symbolic systems can be enhanced. The first is by realistic reassessment of the extrinsic rewards attendant to literacy. This would involve a much clearer communication of the advantages and disadvantages one might expect as a result of being able to read, write, and do sums. Of course, these consequences must be real and not just a matter of educational propaganda. Hypocrisy is easy to detect, and nothing turns motivation off more effectively than the realization that one has been had.

The second way to enhance motivation is to make children aware of how much fun literacy can be. This strategy is preferable on many counts. In the first place, it is something teachers can do something about. Second, it should be easier to implement. It does not require expensive technology, although it does require sensitivity and intelligence, which, some may argue, are harder to come by than the fruits of technology. Third, it is a more efficient and permanent way to empower children with the tools of knowledge. And finally, this strategy is preferable because it adds immensely to the enjoyment learners will take in the use of their abilities, and hence also to the quality of their lives.

LECTURE 6

The Nature of Intelligence

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A discussion of the theory of multiple intelligences and its implications for improving education in America

I doubt that intelligence is only one thing and people have more or less of it. I do not believe intelligence can be measured by standardized tests such as the Stanford-Binet or the SAT. As I have observed children, I have seen that strength in one area simply does not show how strong they might be in other areas. If they were very good musicians or dancers or visual artists or writers, that was no indication if they would also be good in math or science, in understanding other people or themselves, in using their hands or their bodies. One kind of strength does not predict another. This point is even more dramatic with brain damaged people; impairment in one area may leave other areas entirely intact.

Both from developmental evidence, that is what we see when we watch little children, and from neuropsychology, what we see when we examine persons with brain damage, we see that the notion of intelligence as a single capacity is flawed.

Ten years ago I was asked by the Bernard Fandier Foundation, a Dutch foundation, to write a biography on human thinking and the mind, on what has been established in psychology and biology and in areas we now call cognitive science and neuroscience. I was given a lot of resources and five years that culminated in my writing the book *Frames of Mind*. I wanted to pull together my own findings about children and their development and about the brain and its organization. I wanted to account for what it takes to achieve the whole range of adult competencies that are valued throughout the world.

So, I became very interested in sailors in the South Seas who find their way through hundreds, even thousands, of islands without a compass. They do an amazing thing: they look at the configuration of the stars and the skies and at occasional landmarks. They feel the boat sailing through the

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We concluded that the mind is a set of relatively specific, content-sensitive devices, devices that respond to language, to music, to spatial information, to other people, and so on.

water at different depths. From those meager clues they can orient so they do not get lost. If the island chains had a word for smart, it would be someone who can navigate like that because that's important for survival in their society.

I became interested in other kinds of navigators, in pilots, architects, engineers, dancers, artists, hunters, shaman, psychoanalysts, actors, surgeons, a whole range of abilities. I defined the word intelligence as the ability to solve problems or to fashion products, products that cannot be studied in five minutes because they take days or months or years to make. I defined intelligence as the ability to solve problems or to fashion products which are valued in at least one culture.

We looked at what was known about the development of different capacities, how one capacity fits with another, about the break down of different capacities and conditions of brain damage, about special populations, autistic kids, idiot savants, kids with learning disabilities, prodigies, all individuals who had incredibly jagged cognitive profiles.

We also looked at certain notions of intelligence such as transfer — the study of Latin so that you could think more logically or be better at geometry. Many studies showed unendingly that if you studied Latin for the rest of your life, it wouldn't make you the slightest bit more logical or more geometrical.

We concluded that the mind is a set of relatively specific, content-sensitive devices. There are devices that respond to language, a device that responds to music, a device that responds to spatial information, a device that responds to other people, and so on.

A New Theory of Intelligence

I took all this information — development, break down, special populations, current ideas — and tried to figure out as best I could what underlying factors gave rise to these different patterns. I came up with a list of seven human intelligences. It is extremely important to underscore that there is nothing definitive about the number seven — if there are seven I'm sure there are more — and each of them, as I explained in *Frames of Mind*, has subintelligences. But if I were to talk about 237 subintelligences, you would not listen.

The Seven Intelligences

1. Linguistic Intelligence

I had the privilege of taking a course with Robert Lowell, the great American poet. Lowell would go over student poems with us, and when he found a word that interested him, he would tell us how that word was used by literally all the major poets in the English language. It was an incredible performance. His mind was something of a cross between Roget's Thesaurus and the Norton Anthology of English Literature, a superb example of linguistic intelligence.

2. Logical/Mathematical Intelligence

As the name implies, logicians, mathematicians, and scientists have high degrees of logical/mathematical intelligence. Linguistic and mathematical intelligence are very important, but they are especially important for IQ tests. IQ tests are largely blends of linguistic and logical intelligence with a little spatial thrown in. If you have

that particular blend of intelligence, you will score well on intelligence tests, and as long as you stay in school you will think you are just the cat's meow. But there is more to life than language and logic.

3. Musical Intelligence

Some people think musically just as some people think linguistically. Musical intelligence includes conducting, composing, performing, being able to hear a fugue that is transposed.

4. Spatial Intelligence

Chess player, painter, sculptor, architect, navigator, pilot, surgeon, and engineer — a very large range of adult competencies — all have spatial intelligence.

5. Bodily or Kinesthetic Intelligence

This is the ability to use your whole body or parts of your body, like your hands or your mouth, to solve problems or to make something. Athletes, actors, dancers, choreographers, mimes, surgeons, crafts people all have high degrees of kinesthetic intelligence.

6. Interpersonal Intelligence

This intelligence is one of the personal intelligences. It involves understanding other people, how they work, what motivates them, and how to work effectively with them. Teachers, therapists, salesmen, politicians have interpersonal intelligence. Think of Arthur Miller rehearsing "Death of a Salesman." Both the acting and the appreciation of complex drama require a high degree of interpersonal intelligence.

7. Intrapersonal Intelligence

This is the other personal intelligence. It means having a reliable, accurate, and usable model of yourself, your strengths and weaknesses, your intelligences and your stupidities and being able to use that model effectively to solve your problems.

There are two corollaries to the theory of multiple intelligences. One is the assumption that while all of us have some of each intelligence, we don't all have the intelligences to the same degree. As we all have different personalities and different physical appearance, we also have different kinds of minds. This is what makes life interesting. But, the fact that no two people have the same kind of mind is what causes all sorts of problems and challenges for education.

The other is the assumption that life is very short and we simply can't learn everything. We have to make choices about what to learn and even more important how to learn it.

Implications for Schools

The individuality of minds and the fact that we cannot possibly master everything are the strongest arguments against a uniform school system and for individual-centered schools where, in a nutshell, we treat individual differences differently. I would create three new positions for this school.

1. The Assessment Specialist

The Assessment Specialist tries to provide accurate profiles of children's intelligences and a map as they change because profiles of intelli-

All of us have some of each intelligence, but we don't all have the intelligences to the same degree.

Individuality of minds and the fact that we cannot possibly master everything are the strongest arguments against a uniform school system. We have to make choices about what to learn and even more important how to learn it.

One of the key problems in America is the narrow and constrictive nature of our assessment. If we narrow the kinds of tests, they will drive the curriculum.

gence are not static; they change over time. The most important thing is to assess intelligence in a fair way. To do a profile of somebody's intelligence, you have to look at it directly, not in a paper and pencil test. A paper and pencil test smothers it in language and logic because these are the kinds of intelligences that are shown by paper and pencil tests. If you want to know about musical intelligence, teach somebody a song, or teach them to play an instrument, or have them analyze a piece of music. That's what I mean by testing for intelligence.

2. The Student-Curriculum Broker

In the individual-centered school information about the students is fed to the student-curriculum broker who matches students with curricula in two ways. In electives, students are guided toward those subjects where they might be interested because of the kinds of intelligences they have. In mandated subjects, the student-curriculum broker matches students with teachers and with materials which fit especially well with that particular child's style of learning and intelligences.

3. The School-Community Broker

The broker identifies opportunities in the wider community — apprentices, internships, big brother-big sister organizations, professional organizations, craft organizations, artistic organizations — where kids would find something they would like to do, or would find adult models with whom they could identify in a kind of apprentice relationship. The purpose is to give them a chance to gain confidence in areas in which they have some gifts. If kids don't have opportunities to function in their area of intelligence, they will continue to think of themselves as dummies because they don't do as well in school as the brains.

We must find learning opportunities outside school or bring them into school: the single most important thing that can happen in a person's education is to run across something, whether it is a person, a place, an event, or a situation, where the student can say "That is for me; that's more like anything I've wanted to do before." People who connect in the world can identify the time and the situation where they first saw something which was really their own profile of intelligence. The job of the school-community broker is to increase the likelihood that this will happen.

Projects Based on the Theory of Multiple Intelligence

At present there are five projects in which we have an extensive and intense program of research to explore the different dimensions of the theory of multiple intelligences as it can be developed in school and increasingly in the wider community, including institutions like museums. Some projects are taking place in ordinary public schools; others are attempts to create environments where you look at how people naturally use their intelligences. Many of the projects focus on assessment.

If we are going to change American education, we must change testing practices. I am convinced that one of the key problems in America is the narrow and constrictive nature of our assessment procedures. Multiple choice questions, the standard fare of current tests, more often obscure understanding than illuminate it. We can have the

most wonderful teachers, but if we narrow the kinds of assessments, the tests will drive the curriculum.

Arts Propel, a project taking place in Pittsburgh, involves music, visual arts, and imaginative writing. It devises new ways to assess what kids are learning in those three art forms.

We are creating environments where you look at how people use their intelligences naturally. Assessment occurs as a regular part of the curriculum. It occurs almost seamlessly while kids are doing work that is considered to be important. It involves curricula and assessment as one.

A second project, called Catalyst, uses computers to aid student learning in one or another particular area. We are working in musical composition, social studies, and programming. We are trying to develop assessments that will capture on the spot what the students are learning and how they are advancing beyond a novice level.

A third project, PIFS (Practical Intelligence For School), is an effort to help students, particularly in the 6th and 7th grade, know themselves as learners, know the kinds of intelligence they have, and know how to use their intelligence effectively. They gain knowledge of school as an environment, knowledge about other students, about teachers, and how you relate to them; knowledge of the different demands made by different subject matters and different assignments in these subject matters; how to prepare for tests, how to revise a paper, and how to use resources throughout the project.

The fourth project, Key School in Indianapolis, is another project in assessment. This is the only school in the world that is devoted specifically to trying to train each one of the human intelligences. Everyday kids have each of their intelligences stimulated, engaged, and developed. Students put together video portfolios of their projects. We are trying to help them figure out what the students are learning from the different projects.

Project Spectrum in Boston is a collaboration of five years with my colleague, Dr. David Feldman, which studies preschool, kindergarten, and first grade. Initially we set out to establish scientifically that in fact, as my grandmother knew, kids do have very different types of intelligence. We created an environment where, every day in a different way, kids would have particular intelligences stimulated and where we could do things right in the classroom that would help us figure out their profiles of intelligence.

A Spectrum classroom is a very rich environment which throughout the year covers fifteen areas. Teachers watch and help the children interact with materials. Then, spontaneously and naturally, they come up with a profile of the children's particular strengths and weaknesses.

Researchers in the class use more focused kinds of games that allow us to get a more precise picture of children's profiles of intelligence. At the end of the year we issue a Spectrum report, an essay of a couple of pages which describes in plain English the child's profile. It also makes confident suggestions about what the child might be doing in home, in school or in places in the wider community like the YMCA or a children's museum to govern that particular profile of intelligences.

In the classroom we do a lot of work in music. We use Montessori bells. There is a naturalist corner. There are things for exploring numbers, logic

The next ten to fifteen years will determine whether we are serious about turning education around. The greatest risk will be not to take any risk.

and mathematics; kids who do well on a dinosaur board game — reach the ceiling on it as psychologists say — get to play the bus game, a much more challenging game where they actually have to devise some kind of tally system in order to keep track of who gets on or who gets off the bus. There is a story board that gives us a chance to sample language, imagination, personification, dramatic play, and some aspects of spatial knowledge. We have a lot of visual arts — drawing, painting, building with clay. There is bodily kinesthetics — dance, expressive movement, gymnastics, and all kinds of play with your body.

About halfway through the year we bring out a replica of the class, and we ask kids to reconstruct the actual class in miniature. Some do this almost perfectly, but others can't even tell the length and width of the class. Photographs of all the kids and the teachers are pasted on pieces of wood. We ask kids to tell us who plays with whom, what are they doing on that particular day, where the teacher was yesterday. It is an unintrusive way to see their personal intelligences and their understanding observations of other people and themselves. And, it is fun.

In the next ten to fifteen years we are going to determine whether we are serious about turning education around. To do that we need leadership, and we have to learn to take risks. Risks don't always succeed, there are going to be failures, but that is the cost of progress. In my view the far greater risk will be not to take any risk at all.

LECTURE 7

Computers in the Classroom

Bob Hughes
Vice-President
Boeing Corporation
Seattle, Washington

Examples gathered from diverse classrooms of innovative uses of electronic technology

I never thought I would be a lecturer working with educators. I would like to tell you a personal story about how I became a member of a school board. I graduated from college in the mid-sixties and was raising a family and working my way up the corporate ladder with luck and hard work in the Boeing Company. One evening at dinner my son, who was in second grade, and I were talking about school. After dinner, my son started crying. When I asked him why, he said he didn't like school. Later that evening my wife and I talked about what had happened, and she decided to talk to the teacher to find out what the problem was.

The next night my wife and I were discussing what had happened during her visit to the school, and my wife started to cry. I knew then I was in big trouble. I decided I would talk to the teacher. After my discussion, I took a week of vacation and with the permission of the teacher observed in the classroom. This particular teacher had a style of teaching that was very regimented, very stern — the kids had to be ready at the right time, they had to have their pencil up, and if they weren't ready, they got nailed. After a week of observing, I saw that half of the kids in the room were doing very well with that style of leadership and management. But another half, the half my son was in, weren't. They were actually terrified, embarrassed, and having problems. I requested that my son be moved to another class. The administration decided it would not move my son. That decision motivated me to run for the school board. I felt that families ought to be more involved in their children's education. School should be an extension of home. I think that children ought to enjoy school, and I wanted to get involved.

We need people who believe in life-long learning, who can move from job to job, and who are flexible.

The next thing I discovered was that being on a school board does not help your career. You have to be elected. School board members tend to get a lot of publicity. My name's being in the paper wasn't good for my career. Furthermore, it's a voluntary position. Most companies in this country treat work with no pay as of no value; therefore, if you want to attend meetings or conferences, you have to take vacation time. That has since changed in many of our nation's businesses.

Then, the Chairman of the Board of Boeing Company became involved with the Business Roundtable. Thirty-two corporate executives met to decide what they could do as a group to help the economy and their local state. Thirty-two corporate gorillas don't agree, and they all have different opinions about what to do. But, the one thing that they all agreed on was the need for people who believe in lifelong learning, who can move from job to job, and who have a good basic education. They all had the same problem finding trained people who were flexible, had a good base of education, and a positive attitude toward learning. It dawned on them that they needed to work closer with education systems to try to help them improve.

The Chairman of the Board of Boeing, Mr. T. A. Wilson, went back to his company and asked how many of the 157,000 employees were involved in education. The personnel department did not know the answer because they did not track that information — it had not been important to the Boeing Company. By word of mouth they found out that eight employees, including myself, were on local school boards. After visiting with each of the eight, Mr. Wilson requested that I participate in a study on education. Some of the areas he wanted me to look at were teachers' pay, salary benefits, class size and early childhood education. My life has not been the same since. It's like the old story of shaking hands with a tar baby, once the corporate chairman takes hold of your hand, there is no way to let go.

I am in the computer division of Boeing; therefore, one of the areas that fascinated me had to do with technology. In fact, one of the analysts I work with made the statement that schools have no technology. If Rip Van Winkle woke up today, he would be most comfortable in a school because it really hasn't changed in the last 200 years. Looking at the school system today, you would think a chalk board and a transparency projector are the greatest things ever invented. Teaching is a very labor intensive occupation; except for schools, most labor intensive occupations went by the wayside a long time ago. Mr. Wilson asked if I wanted to spend some time trying to influence educators to consider using more technology.

I took on the job. In fact, I told Mr. Wilson that the way you do market research on any product is to visit the potential customers. I traveled all over visiting schools in the Pacific Northwest, Oregon, Washington, and parts of California. I sat in classrooms and talked to teachers. I literally searched for classrooms that had some form of technology, trying to figure out if it worked or not, and what problems teachers had with it. I want to share some of the information with you. One superintendent in Moses Lake said, "You know, everybody in education is doing something, but nobody is doing everything, you just can't. There are too many new ideas emerging."

No matter what kind of technology we are talking about, it is going to be cheaper tomorrow. A number of different industries successfully use

technology to help people. It is not used, as some may fear, to replace people. Technology doesn't replace people. It simply tries to make them more productive, to get more work out of people in the same eight hours.

The following discussion presents an overview of some of the kinds of technology being used in classrooms in America today.

1. Computer Learning Systems

- **WICAT (World Institute of Computer Aided Training):** Based in Utah, this organization developed their own computers and came up with an entirely new way to design software. They hired teachers to design the software instead of programmers who have never taught. They match the software to the curriculum so that a teacher can deliver a lesson, say for 20 minutes, and the kids can use a machine to find out right away whether they understood. If they didn't understand, the machine drops back to a lower learning objective until they get it. As soon as they succeed, the machine records that fact and moves them forward again. The teacher is still in charge, delivering instruction initially, and then monitoring the process as it goes on. It proved to be a very effective system, one of the first to be used in America.

- **Jostens Learning Corporation**: This company purchased Education Systems which used the WICAT model and delivered the same basic kind of software. Jostens put teachers on their staff, developed thousands of programs, and followed the basic text. The main difference was that their software ran on both IBM compatible equipment and on Apple equipment with which about 80 percent of our schools are familiar. Their lab does not replace the existing curriculum or teacher; instead, it provides a system of individualized lessons in reading and mathematics which reinforces what is taught in the classroom. Of course, none of this means much unless the system can accomplish the most difficult task — getting the students' attention. This is one of the many advantages of computers — there is instant motivation. Through automation, they have tried to help a teacher become more productive in the way the teacher currently teaches. Some people consider that inappropriate. They think perhaps we ought to throw out the way teachers teach today and, with technology, offer a whole new method of teaching.

2. Combining Toys with Technology

- **Lego Logo**: Elementary students bring their legos to school; almost every child in America has these little building blocks. They piece them together into robotic characters. They then connect wires and gears and hook the robots to a computer. By using LOGO, an easy to use programming language developed by MIT for kids, they can actually succeed at doing basic robotic maneuvers. Teachers will tell you that some students learn better with their hands, they like to get involved with things, piece them together, and see it. Children who may be very quiet and who have

If Rip Van Winkle woke up today, he would be most comfortable in a school because it hasn't changed in the last 200 years.

not succeeded well in school will, all of a sudden, just explode when working with legos.

- **FisherTech:** A number of junior and senior high schools use this product which is a robot that hooks up to an Apple computer. For example, it can control an elevator to go up and stop. The robotic arm is very similar to what you would see in a factory today. You learn the same techniques with these, for which programmers are paid thousands of dollars each year.

3. Learning Music with Technology

- **Casio Yamaha Keyboards:** In one school there was no band room. There was a long hall with a number of doors. When you opened a door, you didn't hear a thing. The students all had ear phones on and were bumping up and down. They all had Casio or Yamaha keyboards which are hooked up to a computer, and they synthesize sound. Instead of practicing the piano for hours, they can practice the piano and then switch to a violin, cello, drum or whatever they want. In two hours they can play fifteen different instruments which are layered into a computer and then played back. They use a vocalizer to recreate 27 instruments. They created a complete orchestra. In fact, they can be any instrument simply by talking or singing into a little microphone. The problem is that students still have to learn how to keyboard!

4. Laser Disc Technology

The laser disc allows you to store a mass of information. One side of a video disc can hold about 675 carousels full of slides. They are etched and read with laser beams—no needle ever touches the surface. It is a very durable product, fingerprints don't hurt it, and students can't damage it easily.

- **National Gallery of Art:** The Gallery has developed a video disc which is one of the more popular sellers on the West Coast. A disc can be purchased for $95 that has all 1,675 paintings and sculptures on it. The pictures on the disc, which are high quality reproductions, are organized by time period. A teacher can hop around the disc to compare different frames. In seconds you can move from a Leonardo DiVinci painting to one by Salvidore Dali simply by typing a frame number on a hand-held keypad. You can freeze a picture, walk away, and two days later the same picture is there. Some people, instead of buying art work, have a laser disc playing on their television set, and every three minutes a picture comes up from the National Gallery.

- **University of Delaware Music Curriculum:** This is an interesting application in which the music curriculum was put onto three discs which sell for $300. They were having trouble getting students to go beyond writing notes, to picture the whole piece of music. The video disc allowed the instructors to do just that. You actually see the music playing and hear it at the same time. They have also included photographs, paintings, instruments, furni-

ture, and handwriting of the original composers.

- **Systems Impact with Utah State University:** They have developed a video disc curriculum which is used with elementary students in grades five to seven to teach fractions. Using a key pad teachers are able to display things in the front of the room that they otherwise would have to write on a chalkboard. In their study they discovered that teachers have their back to the students for 40 percent of the time; they are writing on a black board or riveted to one part of the room, right next to the transparency projector. With a video disc they can be anywhere they want, including the back of the room, seeing if the students have answered the question and making their presence felt.

There are other laser discs available on various subjects including biology. A disk on whales has been developed by the National Geographic Society.

- **Video Encyclopedia of the 20th Century:** This is an expensive video disc ($11,000) but students using it learn better, faster, cheaper, and have more fun in the process. A video encyclopedia captures our nation's visual history. It contains the kind of movie footage that we have all seen but don't have access to because it is locked away in an ABC, CBS, NBC, or Warner Brother's studio in tape form. CEL acquired rights to this footage and made it available to students in schools. It is simply raw footage of many famous events. If there was sound, then the sound is included. There is no editorial comment. Students can do a report about why we celebrate Martin Luther King's birthday and actually use footage of his speeches. Students get involved in learning by seeing an event as it happened.

- **Video Discover:** They have developed an interface with a MacIntosh computer that actually controls what is on the video disc. There are little thermometers on the computer for temperature, precipitation, elevation, latitude and longitude. You use the mouse to set these thermometers. For instance, you could set the temperature at 60 degrees and the elevation at 6,000 feet. The video disc will then show pictures that were taken at 6,000 feet and 60 degrees — the Alps, the Rocky Mountains, the Cascades. There are 54,000 images on the disc. It is also includes a description of the place and its plant and animal life.

- **Apple Computer 2006:** Apple tried to project what the year 2006 might look like if the current trends in technology continue. A hypothetical example is a student giving a report with a computerized blackboard. He includes a volcano not only with drawings but also with a video of an active volcano—all at the flip of a switch.

- **Texas Physical Science:** They have invented a video disc system hooked up to a computer that delivers a 9th grade physical science course. It has a complete 160 day, one hour-a-day curriculum that is 50 percent technology driven and 50 percent contained on 14 different video discs.

5. Computer Disc Technology

- **Colliers Encyclopedia:** Using search words, information can be obtained very rapidly. The entire encyclopedia can be searched instantaneously. It can also print the information, do a bibliography, and store it a on a disc.

6. Distance Learning

There are all kinds of projects in distance learning in which a teacher is in front of a television camera and can be seen by students across the U.S. With a telephone hook-up we can see each other through new fiber optic methods. For the price of a phone call, a Nobel prize winner can join your class for an hour or two, or you can take a field trip by satellite. Students in Detroit were actually able to interview a scuba diver while he was underwater in the Pacific Ocean. National Geographic is planning on doing other electronic field trips, like treasure hunts in the Mediterranean or walk through a volcano.

I have discovered that an old saying by Pogo is true, "The future isn't what it used to be." Keeping current with these new ideas is not a casual activity; it is something you need to do full time. Somebody in a school district needs to be identified as a technology coordinator to understand the developments, to meet with vendors, to read the journals and to stay current.

I always like to quote famous people when I talk to educators. Mae West said, "If it's worth doing, it's worth doing slow." I would suggest that you don't need to buy a whole lot of anything. You need to buy one or two, find out if it works, find out who is doing it, if it worked well for them, and compare notes before you buy a lot. Go slow. There is a past and there is a future, and as a fourth grader said, "We are in the middle of the past and the future right now."

An evening exploring the exhibits at Capital Children's Museum

LECTURE 8

The Role of Informal Education

Dr. Michael Templeton
Former Program Director for Informal Science Education
National Science Foundation
Portland, Oregon

The National Science Foundation (NSF) has been a long-time supporter of Capital Children's Museum. For five years NSF's Materials Development Center funded a learning lab at The National Learning Center to develop hands-on materials for schools, museums, and independent learners in science at the elementary and middle school levels. Some of the fruits of that project are now in the Museum.

I remember this building from a tour I was given before the Children's Museum owned the building and before any of the things you see were here. It was dark, dusty, and forlorn. It took acts of faith and commitment to see in those empty halls a living children's museum and an energetic and alive educational learning center. Ten years later the results are in. They are a strong endorsement of the faith in the vision that lead to a children's museum in this complex.

I am going to talk about informal science education and out-of-school science learning. In the past ten years there has been a **change in museums and a change in learning**. Museums have moved from being object-centered and object-worshippers to being object-users and object-interpreters. The theory of object-based learning is being replaced by newer ideas about context and content, that objects only become known if you understand the surroundings, what they are for, what people think about them, where they come from, and where they go. Capital Children's Museum is a good reflection of the shift from the view that objects speak for themselves to the view that objects are only part of the conversation a museum has with a visitor.

In the same ten years, out-of-school learning has been legitimized. Informal science learning is a description of a whole collection of processes, all

School has not been the primary source of learning for most of us. We all know things that came not from school, but from the rest of our life. That's informal learning.

of which are learner-centered, not school or teacher or book centered. School has not been the primary source of learning for most of us. School conveys sequential and linear learning sequences. But, we all know things that came not from school, but from the rest of our life. That's informal learning. Conveniently, we spend most of our lives outside school, so it's not surprising that life is a rich environment for learning. That's the starting point for the idea of informal learning or out-of-school learning. How does this happen? Who are the mediators? What are the media? In school the media are the teacher, the classroom, desks and chalkboards, the principal, and the textbook. What are the equivalent media for out-of-school settings?

First, individuals learn in different ways and from no single medium. Some learn by reading magazines and newspapers. Others are close to illiterate in reading text but learn from manipulating objects, from looking at things, from visual manipulation. In a book about 18th century mechanics in United States industrial practice, the comment was made that there was almost nothing written before 1850 on the discipline of engineering in the United States. It wasn't that people didn't engineer, or make new things, or perform new constructions. The Industrial Revolution was well established by 1850. But, it wasn't written down. People talked to each other, showed each other blueprints and models. That's learning.

It's learning from other than printed media. In our era, television, radio, computers, and computer software are all informal learning media. And museums are institutions devoted to out-of-school learning. One of the unique characteristics of all museums is that a primary agenda is the use of a wide variety of media — video discs, television programs, or at Capital Children's Museum, a television, radio, and animation lab. Multiple modalities of learning are exploited by museums.

The characteristics of informal learning are that it's learner-centered, it's individual, and it's almost always voluntary. If a person can walk away or change the TV channel, he cannot be coerced to learn. The museum must engage the visitor. Because of that, motivation is automatic: **if they weren't motivated, they wouldn't be there**. Moreover, **informal learning provides rapid feedback** about whether or not you are engaging the visitor, engaging the learner. Therefore, questions that are the subject of research studies in formal learning settings have obvious answers when you look at a museum or watch kids watching a television program.

Another characteristic of informal learning is that it is non-linear; there is neither a syllabus, nor a scope and sequence. If informal learning is going to be powerful, access to information through informal learning must be reorganized to meet the incoherent, independent, powerful-when-aggregated, but microscopic learning decisions that individuals make. That is hard to do, and that is why evaluations, research, and asking questions about the informal learning process is an essential part of what goes on in the informal learning environment.

It would be nice if we had a theory. But, in the informal learning environment there are very few interesting theories. One, which I call the Null Hypothesis, says that learning in a museum, or learning from television, or learning from reading on your own in a library is just like learning anywhere else except that it happens less often. Little research has been done on informal learning. It's

a field in its infancy. A bibliography on informal learning won't contain more than thirty or forty citations. Only about five studies have ever been published about the naturalistic behavior of families that supports children's learning in their homes. Yet, there have been about 10,000 studies on the behavior of teachers in classrooms.

One anecdote, perhaps a mini theory, is a remarkable constant of science education. It appears that learners who approach a subject for the first time all behave in the same way, regardless of how old they are; this runs against Piaget's theory which lays out stages. Seven-year-olds have the same strategies and the same frustrations as 35-year-olds when they try to hook a light bulb, a battery, and a wire for the first time. **They all go through the same process**. Adults don't do any better than children when asked about the causes of the changing seasons. They have the same problems when asked where gravity comes from. They come to the same incorrect conclusions when asked if man and dinosaurs lived at the same time.

If you have a lot of knowledge, age probably makes a difference. But, when experience is fresh and is unsupported by any previous knowledge of the concept, then adult learners recapitulate the processes and beliefs that children hold. This is a remarkable and liberating fact. In order to feel the joy and delight of being a child once more, seek to learn something that is entirely new for you. That is your goal for tonight.

Informal learning is almost always voluntary. If a person can walk away, he cannot be coerced to learn.

In order to feel like a child once more, seek to learn something that is entirely new for you.

Conclusion

Ann W. Lewin

Objects in a children's museum transcend their intrinsic cultural, scientific, or artistic value: they are used in the service of children's developmental needs, not in the service of collection, preservation and exhibition, which are the raison d' etre of a traditional museum. Objects in children's museums can be manipulated. The emphasis on manipulation is supported by a basic tenet of developmental psychology which was first explicated by Jean Piaget (1947, 1969): learning occurs as the result of one's direct interaction with the environment. Because handling objects is a primary way to explore in children's museums, they are commonly called "hands-on" museums. But, handling alone, as Feuerstein's theory tells us, is not enough to ensure that learning will occur.

More than direct interaction, the critical aspect of children's museums is that they are structurally different from formal education systems. A children's museum is an informal education setting which, unlike a school, is organized according to space, rather than time. Children's museums provide spatial frames, not time frames. Visitors to children's museums do not study in artificial periods measured by ticking clocks and interrupted by bells; rather, they follow an activity for as long as their natural period of interest lasts.

Csikszentmihalyi's theory tells us that interest is the essential factor in learning. The importance of a learning environment organized by space/interest is that it allows concentration to develop. Imagine if Billy Jean King, when learning to play tennis, had been constrained to forty-five minute periods each week, and if, just as she were perfecting her serve, she had to put down her tennis racket and go to golf class. Would she ever have honed her skill? Yet, this is what we ask children to do when we mete out education in arbitrary periods. The organization of a learning environment by space, not time, is in effect a new paradigm for

The critical aspect of children's museums is that they are structurally different from formal education systems.

The structure of a children's museum is, in effect, a new paradigm for a system in which concentration can flow from interest and learning can be contextual.

In a children's museum, information is linked to real experience in a real time in a context which is holistic.

a system in which concentration can flow from interest and learning can be contextual.

Contextual learning, according to John Seely Brown, is perhaps the condition most overlooked in school; yet, recent studies are showing that we learn most when we learn in context. One of the most effective modes of presentation in children's museums is the coupling of a realistic setting with the use of objects which belong in that setting and therefore can be experienced in contextually relevant ways. These settings are built to a child's scale and offer dramatic mini-worlds in which to ponder, wander, explore, try, and even taste. For example, Capital Children's Museum's International Hall presents a foreign country, Mexico, in eight different environments: in the city, visitors actually use the telephones, gas pumps, and (real) vehicles; in the Oaxacan kitchen, visitors actually grind chocolate and make a mixture they can drink; in the Miscellenea, they take real grocery products off the shelves and weigh and measure out goods to be sold; in the Sierra log cabin, they form masa (dough made from ground corn, water, and lime) into cakes which they bake into tortillas and eat — in each instance using real Mexican utensils.

The real importance of learning in context is beginning to be understood as we study the brain and learn more about how it stores information. Recent research suggests that information is stored in a contextual framework which encompasses everything that is related to a specific experience (Springer, Duetsch). This contrasts markedly with the ways we study in school where information is parceled out in discreet bits which are not put in context and are not related to anything that a child experiences outside school. In a children's museum, information is linked to real experience in a context which is holistic. This information is echoed in information they are gleaning elsewhere — newspapers, books, movies, television, and magazines.

Exhibits in children's museums offer excellent ways to integrate information. Exhibits make use of aids which can range from a cave, tomb, forest, fire-fighter's helmet, Eskimo goggles, Indian shadow puppet, oversized balance, or water wheel to a well placed question or explanation. Moreover, these aids usually "work"; that is, "it" will "do" something if you do something to "it"! Because these exhibits respond, children love them. Most important, the "something" a child has to do to get the response varies from exhibit to exhibit. Sometimes a child has to be physical and use his hands, feet, or even his entire body in a way he has never before done. Other times, she has to puzzle something out logically; other times, the solution lies in grasping the spatial relation; or, the solution can only be found through cooperative action with other children.

Howard Gardner's theory of multiple intelligences tells us that children are using all their intelligences as they interact with the exhibits in children's museums. What makes this significant is that school environments rarely draw on more than one or two of the intelligences. Thus, says Gardner, one of the greatest values of a children's museum may lie in the fact that we can see children's strengths through the varied ways in which they respond to the exhibits.

Impressions Five (Lansing, Michigan) created a game in which a huge diagram of the digestive system was painted on the floor. Children's answers to questions about nutrition and eating allowed them to proceed from esophagus to colon

and to learn about the process of digestion as they played. Boston Children's Museum created an exhibit on a factory process having children package, weigh, and put boxes on a conveyer belt. Both exhibits put you physically through a sequence of events to accomplish some end and thus to help you learn how things work by engaging you in the series of logically related events required by the process. Gardner would say that this calls on mathematical/ logical and kinesthetic intelligence.

The Boston Children's Museum laid a huge green rug on the floor to represent a desktop blotter and made the telephone, pencil, paper, ruler, paper clip, and nickel twelve times larger than life. These are handled by children who seem "Lilliputian" in comparison. At the Brooklyn Children's Museum, two huge clear plastic structures, made to resemble the forms of a protein molecule and soap bubble crystal, are analogues to structures in natural objects and are a welcome contrast to the rectilinear world in which we live! These kinds of analogues of reality force children to view what is familiar from a new perspective and to use what Gardner calls spatial intelligence.

The exhibits in children's museums may be the vehicle for a parent to help a child to break through conceptually, to experience him or herself as a competent learner, or to grasp the principle behind a common phenomenon. But, how these breakthroughs come — how we learn — is not fully understood.

David Perkins' theory tells us that there are three kinds of intelligence — neural, what we're born with; knowledge-based, what we acquire slowly throughout our lives; and reflective, the active processing in which we listen to ourselves think. We cannot, Perkins says, do much about the first two, but we can do lots about the third! Only recently have we begun to understand the power of teaching children to think about their own thinking, and this is the least developed area in formal schooling.

The challenge facing children's museums is how to make visitors reflective about their interactions with the exhibits. If we could activate Perkins' "cognitive Jiminy cricket", we could change the interaction between visitor and exhibit into an exchange with the potential to affect the learning process. This is what Feuerstein refers to as the mediated learning experience.

Feuerstein says that there are three partners in the interaction that takes place when we learn:

1. The stimuli —

We want the child to become aware of some particular thing, but we must not leave to chance whether or not the child gets it. The teacher must stand on her head to make sure awareness occurs. The museum must transform the stimuli to make it salient and attractive.

2. The child —

Transform the child, says Feuerstein. If he is asleep, awake him; if she is apathetic, excite her; if they are inattentive, woo and capture them. Make the impenetrable register. Change the child's state of mind. Don't say it's him, CHANGE HIM.

3. The adult —

Change yourself, says Feuerstein. Let the child know, "I'm with you." Become more modest and put yourself within the child's reach.

Children use all their intelligences as they interact with the exhibits in children's museums.

The challenges facing children's museums are whether they can draw adults into the child's learning process and whether they can help children become reflective about their own behavior.

Feuerstein says that the mediator **must change everything**. In museums, if there is no mediator, you must endow the stimuli with all the forces possible to arrest the child's attention; then, don't assume the visitor has gotten it. **The quality of the interaction, says Feuerstein, should be judged by its ability to mediate**.

Children's museums play a distinctly different role in children's learning than either schools or traditional museums. They integrate disparate information and objects in contextually relevant settings which are large-scale, dramatic "lessons", lessons which are beyond the resources of schools and libraries and outside the province of traditional museums. They provide stimuli that elicit a wide range of behaviors and thus tap into abilities that might otherwise never emerge. They offer a neutral, non-judgmental environment in which to erase a self-image of failure. They provide a sense of awe and wonder which piques children's attention, interest, and concentration. They provide analogues and other imaginative ways to stimulate use of all the intelligences. They present opportunities for adults to behave in different ways with children, to enter into new situations and be learners with them rather than teachers, and to make use of the museum's exciting props.

Some of the great challenges facing children's museums are whether they can help adults use these props as effective mediators, whether they can draw adults into the child's learning process, and whether they can help children become reflective about their own behavior.

A children's museum is a vast shopping mall of ideas, materials and techniques to spark inquiry and encourage discovery. Presentation format is limited only by the imagination of the designer. Every exhibit, every presentation, every space, every object, when shaped with clear intent and purpose, is potentially a tool to kindle individual intelligence and to light the bright torch of a child's mind.